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The MONTHLY REVIEW

Published Monthly by the

American Electro-Platers Society

A SOCIETY FOR THE ADVANCEMENT

OF THE

SCIENCE OF ELECTROPLATING

JANUARY, 1932

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CONTENTS — INDEX

	Page
Editorial	4
Annual Meeting Philadelphia Branch	5
The Manufacture of Phonograph Records	7
Anodic Treatment of Aluminum	16
Preparation of Steel Prior to Electroplating	26
The President's Letter	50
Branch News	51
Applications, Elections, Suspensions, Transfer, Deaths	56
Research Committee, Bureau of Education	57
Branch Directory	58

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American Electro-Platers Society

Publication and Editorial Office

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VOL. XIX JANUARY, 1932 No. 1

Notice We are pleased to dedicate the January issue of the MONTHLY REVIEW to the Philadelphia Branch, publishing the complete proceedings of its annual meeting.

Should other branches wish to follow this novel idea we are always glad to co-operate.—*Editor.*

REPORT OF PROCEEDINGS

of the Seventeenth Annual Meeting *of the*

Philadelphia Branch

The American Electro-Platers Society

HELD AT

PHILADELPHIA, PENNSYLVANIA

November 21*st*, 1931

EDITORIAL

Here is something to think about when making your New Year Resolutions. Many of our members are having dreams of what they thought would be good for the Platers' Society, but when it came to putting them in workable shape, they tried having another dream, thereby trying to side-step any effort they would have to put forth in helping to improve the standard of work, or in making conditions better for doing this work.—*Quaker City Platers Reminder.*

The Philadelphia Branch believes and always has thought that the Research Associate should make a monthly or quarterly report in the MONTHLY REVIEW, so that the individual members could become familiar with the Research Committee's work at the Bureau. Philadelphia Branch has only received two reports of the work done at the Bureau, which unfortunately would lead us to believe the Research Bureau has nothing to tell to prospective contributors to the Research Fund. We are sure after five years' work at the Bureau we should be in a position to make regular reports in the MONTHLY REVIEW to all the members, who would then bring up these reports at their branch meetings for discussion, thereby creating an interest in this work.

Those of us who have been in direct touch with the Research work can appreciate how much time is required in research work, but try and prove this to all those who never get a chance to get in touch with the Bureau and the only opportunity they have of knowing what is going on is through the pages of the MONTHLY REVIEW, therefore we should have a report each month of the work done by the Associate at the Bureau, and a quarterly report of the finances of the Research Committee every three months in the REVIEW, showing just who have contributed and the amount, also how the branches raised this money.

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Mrs. Edwin M. Bowers
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This would also be a help to some branches in knowing how to go about raising money and help keep the fund from getting too low.

The Society has gained a certain amount of prestige by maintaining a Research Associate, and to hold this prestige it is necessary to carry along this work and see that it is properly done and reported to all the members and contributors.

The Society, like a great many other concerns, will have their setbacks and reverses during times like we are experiencing just now and which make it necessary that we put our shoulder to the wheel and push forward.

GEO. GEHLING, *Librarian and Editor.*

The regular monthly meeting of the Philadelphia Branch was held at the Harrison Laboratory, President Harry Snyder presiding and all officers present.

Morris Welsh was elected to active membership.

The applications of G. Byron Hogaboom, Jr., and F. L. Macnamara were received and referred to the Board of Managers for investigation.

The Banquet Committee reported the attendance at both the educational session and the banquet was more than we expected it to be and was a grand success. We take this opportunity of thanking our members and guests, especially those from Newark, Waterbury and New Haven, for their attendance.

Charlie Proctor, the founder of the A. E. S., was there to open the educational meeting. Dr. A. K. Graham conducted the educational session, and it was through his good efforts that we had the fine papers that were read and discussed during this meeting.

Letters from President Sievering and Charles Hay were read, and as the branch had already paid for the coming three years, the members voted to donate an additional $50.00 towards the immediate needs of the Research Committee. A welfare committee was also appointed to devise ways and means to raise funds for the Research Committee.

JOS. E. UNDERWOOD, *Secretary.*

The Annual Meeting of the Philadelphia Branch, American Electro-Platers Society, was held in Philadelphia, Pa., Saturday, November 21, at 3:00 p. m., Dr. A. K. Graham presiding.

CHAIRMAN GRAHAM: In accordance with the practice which was established a couple of years ago, we have limited the program today to four papers, with the idea of giving the speakers

ample time to do justice to their subject, and those of you who are interested, the opportunity of discussing the subjects in full.

Before introducing the first speaker, I think it appropriate that we ask the founder of the Society, Mr. Proctor, to say a few words of greeting to us.

MR. CHARLES H. PROCTOR: Mr. Chairman and Gentlemen—I am sure it gives you a great deal of pleasure to be here today, to attend this afternoon session, as it does myself, and I am glad to see, due to the conditions, so many here to attend this meeting, and I certainly hope you have a very interesting meeting, and one that you will long remember.

Of course we are living at present in an unusual time, and when perhaps years from now, some of you may look back, when everything is going along smoothly, and there are no problems in your way, you will remember these very sad days that we are passing through now. But we have passed through them before, and as I look back over a good many years, I have just been counting up the years that I have been connected with electroplating industry, and I have figured out about forty-five years. So, add that on to the number of years that I have lived—I have passed through some of these periods of depression before, and I am going to tell you that if we had the population then as we have it today, they would have been a great deal more serious than they are today.

Now, in looking over your program, I see you have some very interesting papers, and I feel sure you will all enjoy them, and I am going to try to enjoy them myself.

[Applause]

CHAIRMAN GRAHAM: I have another announcement in the nature of a sorrowful one, but I feel it is only appropriate that I should mention that Dr. Lukens, who is a member of the Philadelphia section and an honorary member of the Society, was operated on last night for appendicitis, and is in the Graduate Hospital, here in Philadelphia. The news is that he is doing as satisfactorily as could be, but no one knows until the first two or three days after such an operation whether there are going to be any serious consequences. I know Dr. Lukens planned to be here, and I know it was a great disappointment when he was prevented from coming.

The first speaker on the program is Mr. R. A. Dimon, and he has kindly consented to talk to us on the subject of, "The Manufacture of Phonograph Records."

When I suggested this to Mr. Dimon over the telephone, he assented very readily to my request, and I felt as though we were fortunate in obtaining his services, because there is all too little known about the present art of phonograph reproduction.

I will ask Mr. Dimon if he won't speak to us at this time.

MR. R. A. DIMON: I believe it was the late Senator La Follette, of Wisconsin, who was asked one time how long he could speak continuously without stopping, and he replied that if he had notes, he could speak for four hours; if he didn't have any notes, he could speak indefinitely. So that on account of the number of details and steps that I have to cover in presenting this subject, I am going to read the process as I have it condensed on paper, in order that I won't run over my time.

THE MANUFACTURE OF PHONOGRAPH RECORDS

The electrodeposition of metals has always played a very important rôle in the manufacture of phonograph records. In this paper the entire process involved in the production of a completed record will be briefly outlined with special emphasis placed upon the part of the process involving electrodeposition as being of especial interest to the members of this Society.

The first step in the production of a record is the making of a "wax disc" upon which the original recording can be made. This disc is actually more of a soap than a wax although it contains certain waxes as ingredients. The compositions of waxes used for this purpose vary considerably but all are quite hard and have a relatively high melting point. Their physical properties must be such as to adapt them to recording. The wax is first cast in a disc somewhat larger in diameter than the finished record and about 1½" thick. It is then "roughed out" or machined to the required dimensions and is finally placed on a rapidly rotating turntable and "shaved." This shaving consists of taking two cuts across the surface of the wax, first a rough cut and then a finish cut with two different tools mounted together on a carriage which is automatically fed across the surface of the wax. After the finish cut the wax disc has a very perfect surface which resembles a mirror.

In order to make a recording a shaved wax disc is placed upon the turntable of a recording machine which is constructed to give very true and uniform rotation and an electrical recorder is mounted above the wax on a carriage in such a way as to cause it to feed across the surface of the wax uniformly during the recording. In the case of ordinary commercial records the recording is made from the outside of the wax to the center and in the case of talking picture records the recording is from the center to the outside. Microphones such as are used in radio broadcasting are placed before the artist or musical organization which is to make the recording. The sound waves reaching the microphones are transformed by them into electrical impulses which are amplified by an electrical amplifier. These amplified impulses pass through a fine coil on the electrical recorder and cause the sapphire recording stylus to vibrate in accordance with the original sound waves. In this way a winding groove is cut in the wax disc which is an exact reproduction of the sound waves reaching the microphones. This system has completely replaced the old acoustical recording system in which the sound waves were received in a horn and the recording stylus accentuated by a diaphragm and is far superior to it.

It is now necessary to make from this recorded wax an exact reproduction in metal which can be used for pressing records out of a plastic material. The usual way to accomplish this is to sprinkle very fine copper bronze powder or copper "lining" on the surface of the wax and then thoroughly brush this over the surface with a very fine camel's hair brush. In this way the surface retains sufficient metal powder to become electrically conductive. The metallized wax is then fitted into a suitable holder and placed in an acid copperplating solution. The copper begins to grow from the metal connection on the holder and proceeds to cover the metallized surface of the wax much in the same manner as in electrotyping where graphited wax moulds are covered with copper or nickel.

When the deposit has completely covered the wax an appropriate current density is applied and the copper is built up usually to a thickness of approximately .020". The rate at which this deposition is carried on is limited and governed by several factors. In the first place it is not possible to run these baths at temperatures very much higher than room temperature because of the

danger of softening the wax. In the second place a perfectly smooth deposit must be secured and no chance must be taken of not securing a smooth deposit on this wax recording as only one deposit can be made on each wax and if it must be rejected for any reason the recording is lost and must be repeated.

When the proper thickness of copper has been secured the wax is removed from the bath and the metal shell which has been deposited on it is stripped away from it. This then is an exact duplicate in negative of the original recording and is known as the master matrix shell. In order to secure pressings from this shell it must be "backed up," which consists in soldering or "sweating" the shell to a copper disc about 1/16" thick.

The surface of the shell is then polished and nickelplated and the result is known as the master matrix. While this matrix is not used to obtain any considerable quantity of record pressings directly, a few records known as sample pressings are usually made from it. From these sample pressings it can be determined whether there are any defects in the recording and whether or not this particular recording should be placed on the market. Assuming that this decision is favorable, it is now necessary to produce a number of exact duplicates of this original master matrix in order that the master may be filed away for future reference and also to enable a number of record presses to be placed in operation simultaneously in order to meet the production demands for this particular selection.

In order to do this it is necessary to first make what is known as a master metal mould which cannot itself be used for pressing records inasmuch as it is a positive with respect to the original recording rather than a negative. It can, however, be used for making other matrices which are known as pressing matrices, which can in turn be used on the presses. The procedure for making a master metal mould from the master matrix or for making pressing matrices from the master metal mould is essentially the same. The master matrix or metal mould is thoroughly cleaned and placed in a "separating fluid" which produces what might be called a chemically unclean surface on the metal. In other words, a film is formed which, while being conductive and permitting the deposition of metal, renders it possible to subsequently separate the deposit from the metal on which it was deposited. Electroplaters will be able to understand this by recalling what happens

to nickelplate when the surface upon which it was plated is unintentionally not clean causing the nickel to blister or peal.

After treating in this separating fluid the matrix or mould being duplicated is rinsed and placed in a nickelplating solution where it receives a plate of approximately .0005". It is then rinsed and transferred to a suitable holder and placed in a copperplating bath where it is built up to the required thickness, which is in the case of matrices which are to be backed up about .020". In the case of metal moulds which are not to be used in the presses but only for making additional matrices and are, therefore, not backed up, this is about .030".

The steps just outlined illustrate the two different types of copper deposition which are carried on in the production of matrices. In the one case deposition upon the wax original and in the other case deposition upon a metal matrix or mould which has been treated with a separating fluid. It is impossible to lay down an exact schedule or "family tree" which would hold for definite selections produced inasmuch as this is governed entirely by the demands on that particular selection and the time element. In some cases only a few matrices may be required, in which case only one mould will have to be made. In other cases where a great many pressing matrices are required to produce a large number of records in a relatively short time, it is necessary to produce a master metal mould from the master matrix and then make what are called working master matrices from that. These working master matrices are then used for making what are termed nickel metal moulds, which are in turn used for making pressing matrices. It will be seen that an infinite variety of schedules can be worked out utilizing the two methods of deposition already referred to. For this reason no effort will be made to trace further any particular schedule, but a few details will be given in regard to the methods used in the deposition.

In general the principles of copperplating that have been developed at the Bureau of Standards and the rapid copperplating solutions which were worked out there by Mr. R. O. Hull, who is now on our staff, have proved applicable to the rapid deposition in matrix production.

Our requirements differ, however, from those of the electrotyper, inasmuch as we produce a shell 4 or 5 times as thick and this shell must be smooth on the back and very nearly of uniform

thickness throughout. Uniformity of thickness with respect to the center of the matrix is obtained by rotating the matrix with its center as an axis while it is in the bath. This rotation acts at the same time as a sort of mechanical agitation and tends towards the production of smooth deposits. Uniformity from the center to the outside is not as easily obtained but is approximated by the designing of the plating holders in such a way as to have a hard rubber rim projecting beyond the face of the matrix being deposited. This prevents excessive current density at the edge of the matrix and by the proper design of this holder shells varying in thickness from the extreme center to the outside edge less than 10% of their total thickness can be produced.

The time used to deposit a master matrix shell or a metal mould or pressing matrix shell depends somewhat on the demand for the particular selection involved. It has been found possible to do a large percentage of our deposition slowly at night. In this way work which is received during the day is mounted and placed in the baths in the afternoon and deposited during the night and removed from the baths during the following morning. Not a great deal of time is lost in this way provided that we are working on an 8-hour-day schedule, inasmuch as work received during the day can be ready early the next day. However, it has been found possible to greatly increase the rate of deposition over that used for all-night runs and this is used in cases of extreme demand. The rate used in all-night deposition is approximately .001″ deposit per hour or a current density of 20 amps. per square foot. This can be increased to .010″ per hour, or a current density of 200 amps. per square foot, by the use of solutions high in metal and acid and containing addition agents. The solutions are run at about 40° C. and the agitation is increased by speeding up the rotation of the work.

The finishing of matrices is largely a matter of machining them to the proper dimensions to fit into the presses. Shells which have come from the bath slightly rough are hand-ground on the backs to render them smooth enough to be sweated to 1/16″ thick copper backs. A certain amount of polishing of the nickel faces is done by mounting the matrices on a high-speed spindle and applying liquid polishing solutions with a cloth or brush. In some cases it is possible to remove by hand slight defects which may have crept into the process, using very fine tools. This repairing as it is called

is quite a fine art and must be much more accurately and finely done than is the case with repairing and finishing of electrotypes, as the slightest roughness or imperfections in a groove will result in a click being heard in the finished record which would cause its rejection.

After being machined to the proper diameter the pressing matrices are mounted in the record presses in which they are held by a large circular ring which grips them around the outside diameter. The presses themselves consist of two platens which are drilled through to permit the circulation of steam or cold water and arranged in such a way that they can be quickly opened in book fashion so that they can be brought together quickly and a pressure of approximately 2000 lbs. per square inch applied between them. In making a pressing the operator faces the record press with a steam-heated iron table at his right. Flat rectangular sheets of the record material are placed on the steamtable and softened there by the heat. The operator removes one of these softened sheets with a broad steel knife, folds it twice and places it on the lower matrix of the press. The upper matrix is mounted on a platen which is hinged at the back of the press and this platen is lowered, bringing the two matrices together in a parallel position. The locking device is then closed and the pressure of 2000 lbs. per square inch applied by hydraulic pressure operating under a piston or ram which exerts an upward pressure on the lower matrix. At the time the operator closes the press only high-pressure steam is opened to the coils in the press platens. Almost immediately after the press has been closed and the pressure brought up the steam is automatically shut off and cold water circulated through the coils. The pressure applied to the record material which has been softened by the heat flows it into the grooves of the two matrices and forms a duplicate of these two surfaces. The cooling of the platens by the cold water cools the record material, causing it to harden. When sufficiently hard the press is opened and the record removed. The action of these presses can perhaps best be visualized by picturing a round waffle iron in which the two grids are the two matrices and the batter the record material. The complete cycle required for each record is approximately 30 seconds. During the time that the record is cooling in the press the operator places another sheet of record material on the steamtable to replace the one which he has just removed. In

this way he always has soft material on the steamtable ready to be pressed.

The labels are applied during pressing and are simply laid on the top and bottom matrix over center pins before the record material is placed in the press.

The records are then edged or smoothed on the edge by placing them between two rapidly rotating clamps and applying emery paper at the edge. The records are then completed and are inspected for defects and shipped.

Two recent developments have resulted in the production of two new types of records. One of these is the home recording record, which is a plain groove record having no music and can be recorded upon in the home by using the machines especially designed for this purpose. A microphone is supplied with an ordinary electric Victrola and the pickup is used both as a recorder and a reproducer, using a special blunt needle for both recording and reproducing.

Another type of record which has just recently been placed on the market is the long playing record. In these records the grooves are somewhat finer than the standard records and are considerably closer together. In this way more music is crowded into a given sized record. In addition to this these records are made to reproduce at 33-1/3 r. p. m. rather than the customary 78 r. p. m. and this further increases the playing time of the record. A ten-inch record of this type plays for ten minutes and a 12-inch record for fifteen minutes.[1] Special reproducing needles with sharper points than the ordinary needles are required to reproduce them.

Efforts are constantly being made to improve the quality and usefulness of phonograph records and to simplify the manufacture of these records so as to make them of greater value and benefit to the consumers.

In opening the discussion, I will be very glad to make clear or amplify anything that I have covered, and I might only say that the subject matter included in this has been approved by the officials of the company, and covers practically the entire process, with very little in the way of reservation. I must, however, limit the discussion to the subject matter covered in the paper.

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1 Records are now being made of a recently developed material known as Victrolac, which has considerably reduced the surface scratch or noise.

[Applause]

CHAIRMAN GRAHAM: I am sure we are very glad to have had this very interesting subject presented by one who is so familiar with it, and you will now have the opportunity of asking Mr. Dimon any questions you may have regarding the subject of his paper.

MR. F. C. MESLE: I would just like to ask about how wide that rubber ring is on the outside, and about how uniform the deposit, as the result.

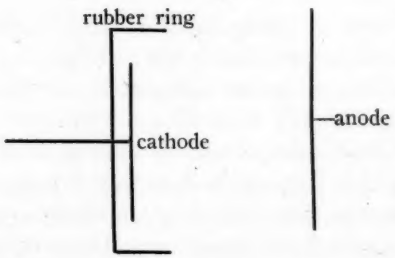
MR. DIMON: The rubber ring projects, I would say, an inch and a half, approximately, forward of the surface of the matrix, and we are able to obtain uniformity of about 10%, I would say, of the total thickness of the shell. That is, if your shell is .020" thick, the variation in thickness from the center to the inside would not be greater than .002". In some cases, it would be a whole lot less than that, but it might be as great as that.

CHAIRMAN GRAHAM: Might I ask, in that same connection, what variation in that figure would be obtained where the actual diameter of the record varies.

MR. DIMON: I don't quite understand that.

CHAIRMAN GRAHAM: In other words, if the ring is 1½" above the surface that is being reproduced, the amount of variation in the thickness of the metal over the surface is going to vary somewhat with the actual diameter of the record itself, is it not?

MR. DIMON: That is what I was referring to. Perhaps I had better make this clear. [Draws diagram.]



Suppose that this surface (cathode) represents the matrix we are reproducing. That is mounted in a holder, a hard rubber holder,

of circular character, and the anode would be hanging over here to the right. This ring prevents excessive deposition of copper here (at edge of cathode). Of course this whole thing is mounted on a spindle with a pulley on it, and is rotated, and that would give us uniformity in a concentric way. Does that answer your question?

CHAIRMAN GRAHAM: Yes. Are all these records of the same diameter?

MR. DIMON: Yes, except that there are 10″ and 12″ records.

CHAIRMAN GRAHAM: Where that diameter varies, do you have to vary this ring?

MR. DIMON: Yes, the rings used for 10″ and 12″ are different.

CHAIRMAN GRAHAM: In other words, there is a variation in the distribution, with the diameter of the record and the actual width of that protective ring?

MR. DIMON: Yes.

MR. CHARLES H. PROCTOR: It would be interesting to know just about how much nickel they deposit on the master matrix.

MR. DIMON: On the master matrix, the nickel deposit is very thin because that is actually in there as an inaccuracy, inasmuch as it is nickelplating rather than nickel facing. Probably it can be measured by three or four hundred-thousandths of an inch. It is just put in the bath a few moments, enough to give it a nickel surface. Of course, in the case of duplicate matrices, the matrices that are placed in the press, the nickelplating is much thicker.

DR. WM. BLUM: I would like to ask Mr. Dimon, what do you find the best separating medium for nickel from nickel.

MR. DIMON: Dichromate, the same as electrotypers use for separating from lead molds.

MR. OPPLINGER: The thought just occurs to me that that principle of the rubber ring around the record might be of some advantage, applied to chromium plating.

CHAIRMAN GRAHAM: Of course, the use of a guard in chromium plating is common practice, but whether plating in that particular shape or not—

MR. OPPLINGER: I know it is common practice, but the principle of extending and changing the length of the ring, depending on the diameter of the record, is a more or less new thing, as far as I am concerned.

CHAIRMAN GRAHAM: If there are any other comments, we will be glad to hear them. If not, we will proceed to the next subject, which I think is one of unusual interest, and it is fortunate that, within the vicinity of Philadelphia, we have several concerns that are doing considerable work in the anodic treatment of aluminum and its alloys. This application is undoubtedly changing continually, and we are fortunate in having one who is active in the work at the Philadelphia Navy Yard, and I am glad to introduce Mr. Edwin Joyce, of the Philadelphia Navy Yard, who is going to speak on the anodic treatment of aluminum.

ANODIC TREATMENT OF ALUMINUM

MR. EDWIN JOYCE: *Mr. Chairman and Members of the Electroplaters' Society*—I had better give you a little history of the reasons for this anodic treatment, and the development of the process.

When aluminum first came into common commercial practice, it was found that it had very good corrosion resistance, and it was predicted that aluminum alloys would also have very good corrosion resistance, but that didn't prove to be the case, and in casting around for some reason for that, one of the British investigators suggested that it was the oxide coating on the aluminum that gave it the corrosion resistance that it had.

There are some well known examples of aluminum which have been in service for years. For instance, the cap on the Washington Monument is of aluminum, purchased at a time when it cost in the neighborhood of $1.00 a pound, I believe.

Mr. Sutton suggested then that if the coating on aluminum alloys was increased in thickness and in continuity, aluminum alloys would also have good corrosion resistance, or have increased corrosion resistance. And two investigators, by the name of Bengough and Stewart, I imagine about eight or nine years ago, made an exhaustive investigation and proposed a method of treatment which has been used without much variation up to the present time.

Now, the method is really described in the title; it is anodic oxidation treatment of aluminum. The aluminum, or aluminum alloy, part is put in a tank containing a chromic acid solution and is made the anode instead of the usual practice of making the part

to be treated a cathode. That is, it is connected to the positive terminal of the generator. The solution, which is of chromic acid, varies in strength from 3% up to 10%, common practice.

As the current passes through, oxygen is generated at the anode and hydrogen at the cathode. The hydrogen escapes and the oxygen is in such an active state chemically that it produces an oxide coating on the part.

It is usual practice to have the steel tank act as a cathode. The current, for good practice, will vary from about two amperes per square foot on smooth-finished aluminum or aluminum alloy, up to say one hundred amperes per square foot on castings and alloys which have higher copper content or higher silicon content. The method is applicable to any parts made out of aluminum, and those made out of aluminum alloys when the copper content doesn't exceed about 5%, and the silicon content is not, say, about 12%. The method is really applicable to all of the commonly used aluminum alloys, that is, those produced by the Aluminum Company as 2's, 3's, 4's, 24's, and 17's,—that is the regular dural composition, —and is not so applicable to castings because of the rough surface. As the roughness increases, the current density increases. And, of course, it is done on a square-foot basis, which means a big generator capacity, as a rule, because the parts treated are generally in sheet form. None of the ferrous alloys, copper alloys, can be treated this way—that is, no oxide coating forms on those. Parts that may have a stiffening ring in them or something like that, made out of steel, will interrupt the treatment because the current passes through the steel part rather than the aluminum part, and as the film forms on the aluminum part, the resistance increases, and when there is steel, there, since there is no film forms on there, with increased voltages, which I will tell you about in a minute, the current simply continues to pass through the steel or brass part instead of oxidizing the surface of the aluminum, it doesn't do any good at all.

The method is rather stereotyped at present. It consists in putting the parts in the bath—this is a batch treatment—taking about an hour's time. The parts are put in there, and beginning with a voltage of about 3 or 4, whatever may be the minimum voltage in the set—it is not necessary to start at zero—starting say at 3 or 4, and in fifteen minutes the voltage is stepped up to 40. It is not necessary to take fifteen minutes to do that, but it is common

practice to do it with a heavy load. Sometimes it will take a half hour. With a light load you can step up just as fast as the capacity of your generator will allow you to. Then, in the next thirty-five minutes, the voltage is held constant at 40. Then in a period from 50 to 55 minutes, the voltage is increased to 50 and maintained for five minutes after which the parts are taken out and rinsed in hot water, to take the chromic acid off; otherwise it stains quite badly, and also it assists in drying the parts.

Now, there is not much leeway in the treatment. A lot of ingenuity is required in suspending parts in the bath, because all the parts that are in contact with the solution have to be aluminum or aluminum alloys, that are capable of taking the treatment. So that in treating rivets, for instance, it would be almost impossible to hang each one on a wire or clip because there are so many of them used. They would be treated in a basket with some means provided to apply pressure to the rivets to cause them to contact one with the other, and the current simply is carried from one small part to the other one, and from there to the sides of the container.

The parts are usually suspended in the same way as cadmium is plated, or copper is plated, from a bar which runs along the length of the tank. The parts treated are generally quite large, so that the tanks used today run from twenty feet up to thirty feet in length, and maybe four or five feet in width.

It is not necessary to submerge the entire part at one time. The usual practice in big bulky things is to treat half of it, turn it over, and secure contact then on the treated part and treat the untreated part as a second operation. There will be an overlap in which the color changes, there is a color difference, but it gives just as good protection from corrosion, so that in calculating the size of the tank to be used, it need be only say one half as large as the largest dimension of any one piece.

Several precautions have to be taken. This oxygen gas of course that produces this oxide coating, may be trapped in a recess of some kind and exclude the solution from that part so that the treatment won't take place on that surface. An article with angles must be placed in the bath with the legs pointing upward. Or if it is a tank that you want to treat the inside, all that is necessary is to provide an opening at the highest point for the gas to escape.

Now, about the nature of the coating. These same investigators

studied these coatings by dissolving the aluminum base from the coating so that they had just the coating left. They analyzed it and so on, and found it to be aluminum oxide having a composition of Al_2O_3, instead of the usual oxide composition that we see in this white powder, which is Al_3O_4. The coating is very dense, and probably one reason it offers good corrosion resistance is because it goes into all the cavities, and the method has such throwing power that it will actually coat, say, the inside of a tube a quarter of an inch in diameter and ten feet long. As the film builds up on the surface, the resistance increases, and therefore the resistance through a longer path becomes of equal value to the resistance of a short path, and the coating then forms farther and farther away from the cathode.

As I said, one of the advantages of the treatment is that it does get in all the cavities, puts this oxide coating on there. The color of the coating is a light gray, often streaked with black, depending somewhat on the surface condition of the metal to be treated. Most of the material treated now is polished, is made with polished rolls. I don't know just what it would look like on a dull surface, such as they are producing now on what they call gray finish, but it has a shiny appearance, often iridescent, and looks very hard, but it is really fragile. It can be easily scratched, and the parts have to be handled very carefully. In fact, they should be painted immediately after they come out, to protect this oxide coating just as much as possible. The thickness of this coating varies from about three to five hundred-thousandths of an inch. The usual zinc coatings, I believe, are about three to five thousandths. Cadmium may be three to five ten-thousandths, and this is three to five one hundred-thousandths of an inch.

The coating is made up chiefly of aluminum oxide, containing some of the impurities which are found in the alloy being treated, such as iron, and a little silicon and a little chromic acid remain, which has not been washed out. A new development, which will probably go into practice one of these days, is to leave the chromic on the coating; that is, to allow it to stain the coating because there is a benefit present of that chromic acid in resisting corrosion. The corrosion I always think of is corrosion by salt water. It is very severe on aluminum alloys. Atmospheric corrosion isn't so hard to combat, and aluminum now used in some of these larger skyscrapers and large buildings, stadiums and so on, in

those cases they don't protect it as a rule. This coating that is formed, however, is from seventy to one hundred times that which is found on aluminum alloys due to atmospheric oxidation. It is almost impossible to get a surface of aluminum that is free from oxide. Even when it is molten, the oxide forms on the surface, and when it solidifies the same action takes place, there is always an oxide coating on there. It is almost impossible to see these oxide coatings, even with a microscope, except after very careful preparation of the specimen.

You perhaps would be interested in knowing the cost of such equipment and how much it costs to oxidize a square foot of aluminum. It will cost about $10,000, I would say, for the purchase and installation of the equipment necessary to treat say four hundred square feet an hour, providing about 1,000 amperes generator capacity, and figuring it at 2 or 2½ amperes per square foot. It isn't good practice to go below 2 amperes per square foot because the coatings then are not as heavy and dense as they should be. It would take probably about four operators to handle 400 square feet an hour, and figuring an operator's time at $5.00 a day, that would be about $20.00 a day for operating expense, plus the current, which figures out about $5.00 a day, and the cost of the solution, which may average for a tank of this size, figuring on 2,000 pounds a year, $2.00 a day, we will say, and then there is more or less wash water required, and incidentals. You can figure out, I think, that treating 300 to 400 square feet an hour will cost about $27.50, or on the basis of seven treatments in eight hours, will cost, say, 2½c per square foot of sheet. That would be less, based on the square feet of area, that is, figuring only one side. The chromic acid solution deteriorates, due to solution of the aluminum and impurities that are contained in the parts to be treated. As the coating starts to form, the current runs up higher in that part of the cycle than any other, and during the first fifteen minutes of treatment, when these cycles come, the capacity of the generator may be exceeded. The first fifteen minutes really determines the capacity of the entire unit. There is some solution of aluminum, but there is a gain in thickness due to this oxide coating which is very small, but then the amount that goes into solution is small. But it causes deterioration of the solution, and there is another factor enters there, and that is the reduction of the chromic oxide, that is, Cr_2O_3, which is reduced,

and that reduction causes an increase in resistance of the bath. We don't know just why. It may be polarization or some other reason.

[Applause]

MR. CHARLES H. PROCTOR: May I ask the gentleman two or three questions?

I am very much interested in your paper, more especially since some time ago I happened to visit a plant in Brooklyn, N. Y., where they had been doing considerable work for the government on aeroplane materials, principally on sheet aluminum, that was anodically treated. They ran into a problem there. I didn't know anything about their proposition, although of course I had read a little upon the subject.

When they first started, they seemed to get clear oxidation on the surface of the aluminum, but eventually ran into a very patchy and dark condition, and had considerable rejected on that account. I was just interested to know if you have any reason for the cause of that.

MR. JOYCE: It seems that previous heat treatment—whether the parts are heat treated in a salt bath, for instance, or possibly some other method of treatment, causes those dark spots. It is also possible that they are caused by the oil that is left on there from the rolls, that isn't removed during treatment. Those dark spots, though, don't seem to damage or decrease the corrosion resistance of the film at all.

There are really two benefits from anodic treatment which I should have mentioned. The first is corrosion resistance. While an ordinary aluminum surface will not withstand salt spray corrosion—it may start even the first day with some of the alloys—the coating that is formed on the alloy most used, that is, duralumin, will last thirty days in the salt spray, and show very little evidence of corrosion in that length of time.

The second benefit is that parts are thoroughly cleaned. There is probably no other way in which you could clean an aluminum surface as well as by anodic treatment, and they are then in excellent shape to receive and retain their paint coatings, which are always applied afterwards.

MR. PROCTOR: Of course, I couldn't offer any solution of the problem. The only suggestion that I made was this—to determine whether the sulphate content of the solution was the same as it

was originally, when the solution was first made up, and if it wasn't, make the addition of sulphate up to the point where it would be equal to the original sulphate content. That was the only answer I could make, and I haven't heard since whether it was good or not.

MR. JOYCE: We worried about the sulphate content for a while, and then decided that it was relatively unimportant. It may cause some deterioration of the solution. We are quite certain that chlorides in the solution cause deterioration, and when they build up high enough, they cause pitting, but that to my knowledge has been experienced only in one plant in this country, and that happened probably in using tap water.

MR. PROCTOR: Those are all the questions I wanted to ask. But this anodic treatment brought to my mind a process that was developed about twenty-five years ago by Elmer Moreland. It must be at least twenty-five years ago. He was in charge of the plating department of the Westinghouse Electric & Manufacturing Company in Newark, and he developed a method of forming an insulation of aluminum borate on the surface of the aluminum, and if I remember correctly, he used a solution of borax. The temperature was quite high. I think it ran up to 160 or 180 degrees, and it was an alternating current at 110 volts.

Now, taking two pieces of aluminum and putting them together, no current would flow through, and two or three years ago, or it might be more than that, Leeds & Northrup in town here were very much interested in such a process, and remembering what had been done by Mr. Moreland, I sent them the information and told them to go to it, that I hadn't done any experimental work myself, but I know that the results were obtained that way. So this anodic treatment, again, is interesting on the basis of what was done for insulating purposes. But I am not sure whether that process has ever been utilized to make it commercial.

MR. C. I. KNECHT: I would like to ask whether there is any appreciable difference in corrosion resistance on the inside of a tube and the outside after being anodically treated.

MR. JOYCE: Very little, because I think the first fifteen minutes of the cycle is more of a preparation, is used to get up to the working voltage of 40, and practically the whole tube is treated inside and out on that voltage. The film is so thin that I don't

really think there is much of an appreciable difference in the inside and outside.

MR. KNECHT: Is there any way of stripping rejected work and reprocessing it?

MR. JOYCE: Oh, yes. It is not a stripping. I wouldn't say that was necessary. You simply put it back in if it did not take a good treatment the first time. The trouble may have been that the contacts were poor, and it is only necessary to put the clamp on again, or whatever way of making the connection may be, and put the piece back in the solution. The contacts have to be made very carefully, because if you don't the current passing through will burn the part that is being treated.

The part may touch the side of the tank, and there is an electrical flash that takes place underneath the surface of the solution —you will get a regular fireworks display. But outside of that, there is not much difficulty in treatment. The most difficult thing is to keep the bath in working order. As it deteriorates, starting say with a 3% solution, you can run on about the capacity mentioned, 400 square feet an hour, in a tank say 25 feet long, and after three months' time the current density begins to decrease and the film gets poor. The correction for that is to add more chromic acid in the solid state, and increase the chromic acid content of the bath. We find, though, after we get up to 7% or 8%, the deterioration becomes more rapid, it is accelerated at those concentrations. Just why, we are not sure—we don't know.

I might say, too, that this anodic coating will pass current in only one direction, and it is used quite a little on aluminum condensers and things of that kind, as lightning arresters.

MR. PHILLIP SIEVERING: I would like to ask the speaker whether the surface will crack and give you the same formation as a tin "cry" will, in bending an article after it is treated.

MR. JOYCE: Not the coating which I described. There is another method, developed by the Aluminum Company, for anodic treating of the parts in a sulphuric acid bath. The coatings are much thicker, and they are very hard, and when a part is bent, you can hear that characteristic cracking noise. It is the usual practice to anodic treat things after they have been formed. You could not do any pressing work, or any work that requires marring of the surface of anodically treated parts.

MR. SIEVERING: Isn't it a fact that by the sulphuric acid method, you can do that?—That you can form them or anything else? It is a certain solution of sulphuric acid that is used. You can do it and still press it or form it as you wish without injuring the coating.

MR. JOYCE: I believe that would be true, because the coating is so hard, it is quite difficult to scratch it unless you use quite a little pressure.

MR. SIEVERING: I would also like to ask what is the advantage of the chromic acid process over the sulphuric acid?

MR. JOYCE: We may be getting into deep water. We have had some samples treated by the sulphuric acid method which were very good, showing excellent resistance to corrosion. But in general I would say they were not so good as the chromic acid method.

There is another benefit from the chromic acid method, and that is you are working with a solution that is not so strong as sulphuric acid. And it is adaptable to plant conditions more than sulphuric acid.

CHAIRMAN GRAHAM: Are there any other questions?

MR. ALBERT HIRSCH: Did I understand him to say it was possible to plate the inside of a quarter-inch tube ten feet long?

MR. JOYCE: That is right. That is an approximation.

In treating tanks, for instance, of say 150-gallon capacity, if you have an opening two inches in diameter, and fill the tank with solution, it will plate inside just as well as on the outside.

DR. WM. BLUM: Amplifying one statement Mr. Joyce made, the difference between the sulphuric and chromic acid processes, Mr. Joyce implied that it might actually be an advantage to have a small amount of the chromic acid left in the coating, in the film. It seems to increase the protection, whereas with the sulphuric acid process, if you have any sulphuric acid left, in the seams or in the joints or anything of that sort, it is more likely to cause corrosion afterwards. That is one limitation of that process.

MR. SIEVERING: I was going to ask that. Isn't that somewhat objectionable in commercial work, to regulate your current from 5 to 10 ampere volts up to 30 or 40 or 50, which you don't have to do with the sulphuric acid bath.

MR. JOYCE: The chromic acid treatment has the disadvantage that it is a batch treatment, and requires an operator in attendance all during the treatment. As the resistance in the circuit is de-

creased, you have to get increased voltage by means of a rheostat or something of that kind. The sulphuric acid treatment is carried out in a 25% solution, about 25 volts, and has a current density of about 10 amperes per square foot of surface. It requires about thirty to forty minutes of treatment. There might be a saving in operating costs, using that treatment, although it may be possible also that the anodic treatment by means of chromic acid may be developed where it will become continuous too. The only reason for having this fifteen-minute period to start with is to get up to the 40 volts without exceeding the generator capacity.

MR. BOOTH: One question I would like to ask—that is, is that a dichromate formation?

MR. JOYCE: No, it is an aluminum oxide that forms on the surface.

MR. LONG: Does metal plate out of the solution on the tank, or does it oxidize into trivalent chromium?

MR. JOYCE: You mean is there any chromium plated out?

MR. LONG: Yes.

MR. JOYCE: No, the current densities, I don't believe are high enough for that. There is, though, a deterioration of solution, a change from chromic acid to the reduced form.

MR. LONG: That is what happens instead of plating out?

MR. JOYCE: Yes, but I don't believe that an equivalent quantity is changed.

CHAIRMAN GRAHAM: In other words, some of your chromic acid is being revenerated at the anode during the anodic treatment, at the same time you are having a certain reduction at your cathode. But the current density you have there at the cathode is so low that you are not plating metal.

MR. JOYCE: Probably.

CHAIRMAN GRAHAM: I would like to ask a question about those contacts. Where you have to use aluminum or aluminum alloy contacts in racking your work in the tank, what limitations do you meet when the actual racks themselves have received this anodic coating? Does that not offer a contact resistance which makes it difficult to get contact with your piece, and if so, does it have to be removed?

MR. JOYCE: That is true. The film that is formed has a high resistance and has to be taken off by some means before attachment to the part. Except that the film is so fragile that if you have

anything that screws down, we will say, just a mere screwing it down there will break that coating.

One method they use to attach parts to the rack is to have a coil spring with certain parts between the spring coils. It sometimes becomes necessary, after the spring has been used for a number of treatments, to send it over and have it sand-blasted or pickled.

And in making the double treatment, you always have to rupture that film in some way. And wherever there is a contact of course that contact remains untreated, that is a weak spot. But it is of very, very small area.

MR. LONG: Is it possible to remove that with caustic soda?

MR. JOYCE: Yes, that is very easily done.

CHAIRMAN GRAHAM: If there are no other comments, I see we have just about used up our time, and we will proceed with the next topic.

I was very much interested when we first started to plan this program in the idea of having a so-called "All Philadelphia" program. We have quite a little Philadelphia talent on the program, if you look, and when we had to go out of Philadelphia for talent, I might say that we went out after a pretty good man. In introducing the next speaker, I don't know that he needs any introduction, but, frankly, I know of no one who has contributed more individually to the advancement of electroplating than our next speaker, and I am sure that what he has to tell us on the preparation of steel prior to electroplating will be worth listening to. Mr. George Hogaboom, of the Hanson-Van Winkle-Munning Co.

MR. GEORGE B. HOGABOOM: I am pleased to have this opportunity of talking to you this afternoon. Philadelphia has always had a warm place in my heart. I believe I was at the first meeting that the Philadelphia Branch ever held, and naturally I am glad to be here at the Seventeenth Annual Meeting, and talk to you about

PREPARATION OF STEEL PRIOR TO ELECTROPLATING

It is within the memory of those here today that a definite program for studying the problem of finishing and electroplating metals was begun. Previous to this time each plater seemingly

stood alone and fought his way out of difficulties the best he could. When the problem defied all his efforts—and this was not until an untold amount of work was done and along with it the toll-taking worry—the cause was laid to something that could not be controlled and the attendant losses had to be accepted. This something was nearly always considered to be in the plating solution. It is no wonder then that the first definite efforts to help the plater with his problems were along the lines of the control of the plating solution. This was hailed as a great step forward, in fact the only real movement that had ever been started that would bring out concrete facts which when properly assembled would indicate the direction for the plater to travel so as to get out of the woods of discouraging difficulties.

The first effort toward this was the bringing of platers together where the problems could be discussed and help obtained from the experience of others. The American Electro-Platers' Society has in its short life done more for the plating industry than could have been done through any other channel. Any scientific organization would have been a failure. It could not have reached the men who gave the very best part of their lives, not alone to earning a living for themselves and their dependents, but to the development of their accepted vocation—finishing and electroplating. With all of the difficulties ever present they turned out work of a character and quality that demands today the unqualified admiration of research engineers, members of scientific organizations, who now have become interested in the art of electroplating.

The need of some means to bring about a better comprehension of electroplating problems and to create a closer understanding between manufacturers of materials that entered into electroplating processes was emphasized in the beginning of the World War. Engineers looked upon electroplating methods in the same way that they viewed some mechanical process and drew up specifications which were not understandable to the plater and which were not possible to meet. This situation resulted in a conference at the U. S. Bureau of Standards and was the means of interesting that bureau in the problems of the plater. What has been accomplished by Dr. William Blum and his associates since that time is too well known and appreciated to need any comment before a meeting of platers. The one outstanding feature, however, that deserves mention is that the late Dr. S. W. Stratton, then Chief of the Bureau,

and Dr. Blum, instead of bringing together a number of scientific men, turned for assistance to the American Electro-Platers' Society, to the men who were broad enough to get together and discuss their problems. This association of the Bureau and of the American Electro-Platers' Society has become closer each year; at first general problems were looked into, then specific problems and the constitution and control of plating solutions were studied; research associates supported by the American Electro-Platers' Society going still further into the principles upon which electroplating is based, are now a part of the work, and they not only should be, but must be, loyally supported.

Industry, which had looked so often with closed eyes upon electroplating troubles, also became aware that if the same amount of directed effort were put into their electroplating processes as was put into their mechanical ones their product would be improved and their costs decreased. In many plants the plating room was taken from the cellar and placed on the top floor. More attention was given to equipment and to control of plating solutions. Today, the electrodeposits are being intensively investigated so as to learn what influence a metal plated under controlled conditions, both chemical and electrical, has upon the desired protection from corrosion.

It seems strange in all this work that the investigations should have been from the top to the bottom; yet how could it have been done otherwise? Without fully realizing it, those who directed or actually did the work were building a foundation, may I call it, with the superstructure. Had the metal to be processed been studied in the beginning, there would have been no way by which it could be definitely stated that the quality of the work obtained was attributable to the base metal, its preparation, or to the plating operations. The latter are now generally known and controlled. The effect of composition of the solution, the ratio content of the several ingredients, temperature, current density, and the time of deposit are fairly well established. The preparation of the work and its effect upon any or all of the known factors can now be more intelligently studied, and that should be the next problem. We know too little about it; and until it is understood, any deduction drawn from the data obtained from methods used or from products obtained will have to be taken without the assurance that better results could not have been had if the effect of the character

of the metal receiving the deposit and the preparation of the surface had been known.

You recall the discussion of Walter Fraine and Clarence Van Dereau on my paper presented at the Detroit convention. It is not necessary to comment upon what was said regarding the trouble experienced with cold rolled steel, but attention may well be called to the most important point that the physical character of the steel had a direct bearing upon the quality of the deposit obtained. The plater, no matter how ingenious he may be or how well he controls the plating solutions, cannot cover imperfections in steel stock that are due to the method of manufacture. The economy in fabrication of this grade of steel when it is to be electroplated is offset by the increased cost of finishing and plating, and at best the completed article bears the stamp of inferiority.

The physical condition of the stock is not all that the plater has to contend with, especially if the steel is to be plated directly after forming, that is, without any polishing operation. There is the material put on the steel to prevent it from corrosion. It is generally referred to as an oil, but often it is a residue of some process in the oil industry. It seems at times as if all the active qualities of this oil have been taken out, as it resists emulsifying and can only be removed by wetting it with kerosene, diluting it with benzine or gasoline, or exposing it to the hot vapors of a solvent that leaves the solids on the work. After any of these treatments, alkali solutions must be used and followed by an acid pickle. What a help it would be to plating industry if there were a coöperative research by manufacturers of steel, fabricators of metal and electroplaters.

It is well not to attempt to remove a coating put on by the steel mill to protect the steel from rusting with a caustic alkali. If the cleaning solution is violently boiled, or when an electric cleaner is used at pressure of 12 volts, the oil is forced from the surface of the steel and collects on the top of the cleaning solution. Soaps or other emulsifying agents are often added to caustic alkali cleaners with the hope that there will be a double action—the emulsification of the mineral oils by the soap and the removal of the emulsified material by the caustic alkali. In many cases this will be found to be good practice; but if much soap is present, such a cleaner cannot be used as an electric cleaner. The suds formed will hold the hydrogen gas developed; and if there is an electric spark, an ex-

plosion will take place. At times the explosion may be so violent that the cleaning solution will be forced out of the tank—a very dangerous method to use. The best practice is to use the two-cleaner method: a soap solution to emulsify the mineral oils and to remove the majority of the greases or compounds, and a caustic alkali bath used either as immersion or with the current as an electric cleaner.

Steel is cleaned better in an electric cleaner. A direct current should be used, but this may be followed by a few moments of reverse current. Both the direct and the reverse current should not be used in the same solution. It is known that at times this is done, but the practice is not good and cannot be recommended. If there are products in the compounds used to protect or polish the steel that are soluble in a caustic bath, they will readily go into solution when the reverse current is used and will deposit upon the work with the direct current. Many compounds that are not chemically soluble in a cleaner are electrochemically attacked and go into solution. Another source of often invisible difficulty is the presence of colloids in the cleaner. Under certain conditions, and these conditions often exist in a cleaning solution, colloids are deposited upon the work. They are generally of a gelatinous nature and are not easily detected. If strong acids are not used to remove the deposit of colloids, they will adhere to the work; and many cases have been seen where pitting and rough deposits were directly traceable to them.

If solid particles adhere to the work after the oils and greases have been removed, they may be removed by the use of a reverse current. This, however, should be done in a separate cleaning solution. It is a safety factor that often prevents much trouble which is difficult to locate. At times there is so much heavy material on the work that the cleaning methods, even when functioning well, fail to completely remove. Gasoline or benzine is resorted to, but this should be avoided wherever possible. It has been found that kerosene oil will thoroughly wet these heavy materials and even remove some of them. Kerosene is easily emulsified in a soap solution, especially if the work is agitated, and therefore much labor and expense can be saved if it is used just previous to the soap soak. There need be no rinsing after the kerosene oil dip. While there are no definite data to prove it, there is every evidence that the presence of kerosene oil in a soap soak improves it and assists in

decreasing the cleaning time. It is also known that what is left on the work after it comes from such a soap soak is readily removed in the electric cleaner. A hot water rinse should follow any cleaner in which soap is used or in which a soap is formed by the greases removed and the cleaning compounds. Cold water will congeal a soap film on the work and when put into an acid pickle an insoluble soap film will be formed. Such a film is difficult to remove in an alkali cleaner; and if the work is rinsed in cold water alone after the acid pickle, there is the probability that the metal deposited will not have a good bond to the base. One of the distinct advantages of a hot cyanide copper deposit on steel previous to the nickel is not that the nickel adheres better to the copper, but because the hot copper cyanide solution has acted as an electric cleaner and plater and removed films that have been often unknowingly left on the work.

The acid pickling of steel after alkali cleaning is a most important process and one to which too little attention has been given by the plater. Sulphuric acid, hydrochloric acid, or sometimes nitric acid is used in varying strengths. The control of the strength of the acids is almost an unknown procedure. Work covered with an alkali film is swished through a rinse water, rushed through a pickle, again rinsed in the same water as used for alkali rinsing, and hung in the plating solution. How long is the acid pickle really effective? The plating solution is carefully controlled by analysis; the alkali cleaners must be magical in their power to remove greases or oils, and yet, so often, the very process that will do more than any of the other preparatory cleaning methods is run strictly on a rule of thumb basis. Work from which all grease or oil has not been removed will not plate well; the deposit will not be adherent. Work that is not properly pickled may have a seemingly adherent plate, but there is no bond between the deposit and the base metal. Today, with the insistent demand for better electroplated coatings that will afford a reasonable degree of protection against corrosion, there must be a good bond, in fact, a bond as perfect as possible to obtain. When chromium-plating recently was accepted as a finish, the plater was surprised to learn that he was not obtaining a bond of the electroplated nickel—there was peeling when chromium was applied. With all its success as an ornamental coating, chromium would have been a failure if the plater had not learned how to bond the nickel deposit to the base metal. All of you

know too well the vast number of failures that occurred in the early days of chromium-plating, and were these not due to the lack of knowledge of how to prepare the base metal? When that was understood and accomplished, chromium-plating was established.

Is this not true of all electroplated coatings? Is the same attention being paid to the necessity of correctly preparing the surface of the steel for a coating of cadmium or zinc? Can the same degree of protection against corrosion be had on just a cleaned surface as upon a surface that has been prepared so that there is a perfect bond between the cadmium or zinc and the base metal? There can be but one answer—all electroplated coatings must be bonded to the base metal if the quality of electroplating is to be improved and maintained at a standard that will compete with any special alloy metal.

Immersion acid pickling can be used with success on cold rolled steel or upon steel that has been polished. The strength of acid and the time of pickling should be such that the surface is slightly, yet imperceptibly etched. In the working or polishing of steel a thin amorphous skin is formed on the surface. If this is not removed or broken through, there will not be a bond of the electrodeposited metal. This is illustrated on page 111 of the "Principles of Electroplating and Electroforming"—revised edition. It will be seen when the "skin" caused by polishing is not removed that the deposited metal seems separated from the base metal. When the "skin" is removed by pickling, the structure of the electrodeposit follows the structure of the base metal, and there is evidence of a perfect bonding.

Electropickling, while long known, has not been generally adopted because of the condition of the work after being processed. The methods have been studied and improved, and today one is being used with much success. It is not advisable to attempt to use the same pickling process for all classes of work. For cold rolled steel or for polished work, a sulphuric acid pickle of varying strength can be used with direct current. A 32 degree Baumé sulphuric acid is being used for this class of work. The time of pickling is from one to three minutes. This pickle is not for the removal of rust or scale, but for the preparation of the surface of the steel so that a bonding of the electrodeposit will be had.

Work that has a scale because of annealing or forging can be treated in an electric pickling process developed in the laboratory

of Hanson-Munning Company. It not only pickles the work, i.e., removes the scale, but it also brightens the steel so that it has the appearance of having been plated. By this process all scale, even that in the deepest pits, is removed; and the steel is in a perfect condition to be polished or to receive an electrodeposit directly. A considerable saving can be made if forgings are electro bright dipped previous to the polishing operation. Scale is hard, often glass hard; and considerable abrasive must be used to remove it. A coarse-grain abrasive is necessary, and when part of the scale is removed this coarse abrasive cuts deeply into the metal and makes the subsequent polishing operations more difficult and expensive. If the scale is removed, the polishing can be started with a finer abrasive, the time of operation decreased, and the quality of the finish improved. There is no evidence of the cuts left by a coarse abrasive or of the necessity of using a cross-polishing operation.

When steel with scale is polished, it is not possible to remove the particles of scale in the fine pits or in the pores of the metal. Adherent electrodeposits cannot be had on scale. Where there is scale in the pits, the deposit will be thin, due to the fact that it has had to creep or bridge over the scale—the scale acting to electrodeposition as a graphited surface—the deposit gradually spreading over it rather than immediately covering. These thin spots give a false impression of the amount of metal deposited as they indicate in a salt spray, Preece test, or in any accelerated corrosion test the provocative life of the electrocoating.

If the steel is processed in the Hanson-Munning Bright Dip, it is absolutely free from scale. Any electrodeposit will take all over immediately, and there will be a perfect bonding. A bright dipped steel can be given a clean, clear coating of cadmium or zinc in 10 seconds at as low a current density as 10 ampere/sq. ft. This coating, of course, is not sufficient for protection, but it proves that the surface of the steel is far more clean and in a better condition to receive an electrodeposit than steel that has been pickled by immersion. Such a steel, cadmium or zinc plated under the same conditions, requires from three to five minutes to obtain a clear coating. An acid copper coating obtained by immersion in one second is clear and so adherent that it will withstand scratch brushing with a steel wire wheel. Electrogalvanized conduit pipe withstands from two to three one-minute Preece tests more than when pickled by the best known immersion process. The weak

spots caused by scale inclusions which are thinly coated by electrogalvanizing are not present—the electrodeposit of zinc is continuous and uniform over the entire surface. On bumper bars not only is the cost of polishing operations decreased, but also the salt spray life with the same amount of electrocoating is increased. The deposit upon a Hanson-Munning bright dipped steel is bonded to the base metal in a manner that has never before been accomplished. There is no secret reason—it is self-evident—the surface of the steel is clean and free from passivity.

At this time, when electroplated coatings are being compared more closely than ever in the history of electroplating, it is essential that every precaution be used to clean steel in such a manner that there will be a perfect bonding of the deposit and the base metal so that the greatest amount of protection against corrosion be obtained.

[Applause]

CHAIRMAN GRAHAM: I know I was right, now. What Mr. Hogaboom had to say was certainly worth listening to. I am sure that he has touched on so many affairs of plating in discussing the preparation of steel for any type of plating that there are any number of you that might have questions to ask Mr. Hogaboom.

MR. R. A. DIMON: That copper-plated sample you just handed out, do I understand that was simply dipped without any current?

MR. HOGABOOM: Yes, just immersion; put in and taken out as fast as we could get it in and out. No current. It just shows you the surface is not passive; it is absolutely active, because it wouldn't take the copper unless it was.

MR. ROBERTS: Might I ask what cleaning process is gone through with before you use that electric pickle?

MR. HOGABOOM: Just an electric cleaner.

MR. ROBERTS: Electric alkali cleaner?

MR. HOGABOOM: Yes, just leave it in two, three or five minutes. We are cleaning bumper bars in three minutes in an electric cleaner, and then the pickling operation is about five minutes, and they are coming out just the same as you see that piece of forged steel there. All the scale and everything is removed, and that is done on a full automatic so that the time must be constant.

MR. ROBERTS: Will that remove a dark graphitic deposit which is left after trying to clean off your oil and you still have this black deposit?

MR. HOGABOOM: Yes, the work can be either electrically pickled or pickled by immersion, and can be treated in this way and will come out and all graphite will be removed.

MR. ROBERTS: There are two tanks required in that operation?

MR. HOGABOOM: If you want to electric pickle, two tanks; if you are prepickling, one tank.

MR. DIMON: Were you using two tanks to electric clean these?

MR. HOGABOOM: Electric cleaner and two pickles. In case it is wire, we do not do it. We are cleaning wire in fifteen seconds, that has been annealed.

MR. JOYCE: I just wanted to know how far will that throw. I don't know any other way to put it. Will it clean the inside of a spring, say?

MR. HOGABOOM: It has quite good throwing power, that is, quite good cleaning power in recesses, yes.

MR. JOYCE: What about embrittlement? Is there any gas embrittlement?

MR. HOGABOOM: Very, very little.

MR. SIEVERING: Is that applicable to all classes of steel, such as stainless steel, Allegheny metal, and so forth?

MR. HOGABOOM: We have had some steel that could not be processed. Of course, carbon steels are best, but we have processed chromium steels and 18-8 steels.

MR. PROCTOR: I would like to ask Mr. Hogaboom whether he has any knowledge of the Nevins patent of pickling—Nevins Tool Company, of Philadelphia. The point of information that I am trying to get is this, whether this process has any comparison with what might be termed the Nevins patent of pickling. I think their patent has about two years to run, and of course that was both an anodic and cathodic process.

MR. HOGABOOM: Yes, we have noted a number of anodic and cathodic processes of pickling. Our work has indicated that we have arrived at a point so that not only is the work pickled, but it is cleaned. Pickling may mean only that the work comes out bright. In here, the work comes out bright and clean; regardless of what may be on it, it is removed. Our conditions are controlled.

MR. OPPLINGER: Is there any possibility with this process you describe of overpickling work? Say, for instance, if you have parts which are covered with very heavy rust in some places that might possibly take in ordinary pickling, an hour and a half or an hour

to remove, whereas some other part of the work has only a light rust. Is there any possibility of it being overpickled?

MR. HOGABOOM: No, because the time in this bright dip has never exceeded two minutes. It is two pickles if you want to use the electropickle, or prepickling, if it is prepickled, it is cathodic and therefore the amount of metal removed is nil. But in the reverse current the pickling process has never been over two minutes, and generally one minute.

LT. WILLINK: I just want to make mention of another process of cleaning metal prior to plating, or prior to any other use, and that is the use of a chlorinated organic substance in vapor. I know several manufacturers are using that with a great deal of success. It has limitations on parts that have large recesses, where the vapor is likely to collect, but for the average flat work it is extremely satisfactory.

CHAIRMAN GRAHAM: Might I make a comment on that? Where you are using a vapor cleaner, you are removing chemical dirt or grease which is soluble in the vapor, but you do not have an electrolyte, and consequently you do not have an electrolytic attack of the metal, analogous to pickling, and where that is the case, you would not be removing either oxide or the smut or film analogous to what this particular paper deals with.

LT. WILLINK: The vapor cleaner is used for soaps and alkali, which of course fits in with this same kind of cleaning.

CHAIRMAN GRAHAM: I didn't want to have any misunderstanding between the relation of Lt. Willink's remarks and the discussion of the paper itself.

MR. MESLE: I have several questions I would like to ask. I think Mr. Hogaboom suggested the passing of work from kerosene to soap as a cleaning process. Does not that method soon destroy the effectiveness of the soap?

MR. HOGABOOM: We have not found it to be so, Mr. Mesle. We have been using it quite a long time.

MR. MESLE: That seems to be our experience. It works very nice for a while, but the soap soon—well, it just dies, and we have to throw it out.

MR. HOGABOOM: We have been using it quite some time, and using it very successfully.

CHAIRMAN GRAHAM: I might ask Mr. Mesle if he is not in a district where the water contains quite a high chloride content?

MR. MESLE: Fairly high, yes.

CHAIRMAN GRAHAM: Because that would have a tendency to destroy your soap solution.

MR. MESLE: That has been our experience with it.

The other question is, how dependent is successful bonding of the plate on the anchorage affected by etching? What I mean is, is etching necessary to get the right bond or the right appearance in a plating process, or does it just help when the bond isn't so good, as in the case of aluminum?

MR. HOGABOOM: In the case of aluminum, it is strictly an anchorage. In the case of other metals, I am wondering whether it is not more of what I spoke of on Page 11 of the book by Dr. Blum and myself. [Draws diagram.]

If you look at that, you see a crystal structure of a piece of metal, and if that is polished, you will find that you will have a "flowed" surface on that metal. Now, if you electrodeposit on that with copper, the structure of your deposit will be similar to that. [a]

Now, let us take the same crystal structure here, and you pickle that and remove that flowed surface, you actually follow the crystal structure here, and Dr. Blum has done very excellent work on that, and Dr. Graham did some work on silver, where we have never yet been able to find where the base metal left off and the electroplate stopped. (See diagram below.)

Because you have got a perfect following of the structure of the base metal. In that way, you evidently have a perfect bonding, without an anchorage such as you would get by etching aluminum.

In this first illustration, you have that worked surface and you are getting an entirely different thing, and while the plate may be partially adherent, it is not absolutely bonded.

MR. MESLE: Another point I had in mind,—it is perhaps an old argument between George and me, and that is, while we take in the case of steel or any metal, while the successful plating is dependent somewhat on the structure of the base, can't we do things in the plating of steel that will offset that in a measure?

This is what I have in mind. We had one time some soft steel handles, knife handles, and they were assembled full of seams. Whenever we plated those, by going from an acid cleaning to an alkali solution, those seams were very apparent. But if instead of going from the acid cleaner to an alkali solution, we plated in an acid solution, as in nickel, the seams were not apparent. I just mention that.

MR. HOGABOOM: Well, in one case, where you have your steel, and you are putting it directly into a cyanide solution, probably the structure of one metal is following the other, and in the case where you put on nickel, you have a metal that has an entirely different structure. Look at the work of Blum and his associates on alternate copper-nickel deposits. He prevented the copper crystals from growing, just by interspersing a metal that had a very fine structure, such as nickel, and therefore the following metal was good.

We have found in a large number of cases that it is not good practice to go from acid to an alkali, or alkali to a direct acid, because it always seems to affect the structure.

MR. MESLE: In plating these knives, we do go from an acid pickle to an acid solution, knowing that. That is why I mentioned that.

MR. ROBERTS: Will that process have any effect on work which is to have a very bright finish? For instance, will it etch the steel in such a way that work which is to have a bright finish will be marred, and have a dull appearance?

MR. HOGABOOM: I state in my paper that if it is cold rolled steel, and polished, it is a great deal better to use the direct current with sulphuric acid, in which case you can get a bright finish, and get sufficient etching so that you get a perfect bonding. We have here Mr. Sizelove, who is plating an alloy steel with nickel, so as to have a mirror for a vanity box. Now, the successful operation of that, I believe, was due to the fact that after the steel is burnished, and has a high luster to it, using it as the cathode in a sulphuric acid pickle. Am I right, Mr. Sizelove?

MR. SIZELOVE: Yes.

MR. OPPLINGER: Lieutenant Willink brought up the question of the difference of plating cold rolled and hot rolled steel. Now, it has always been my impression that there was considerable difference, and I somehow or other gained the impression that it was somewhat simpler to plate hot rolled than cold rolled steel, that is, not referring necessarily to bonding or anything like that, but referring more particularly to the appearance of the coating.

Now, I may be wrong, but I would be interested in having somebody else's comments on just that thing. What I refer to was, for instance, Mr. Hogaboom has plated with cadmium for ten seconds on two pieces of conduit pipe. Now, I would expect that if one of those pieces was hot rolled and the other was cold rolled and cleaned, you would get a better deposit in ten seconds on the hot rolled than on the cold rolled. Now, I may be wrong, but I would be interested in getting some comment on it, because there is an appreciable difference. I have never been quite sure just what that difference was.

MR. HOGABOOM: It is entirely due to the structure of the metal, and due to the method of manufacture. Cold rolled steel is pickled, and then fabricated, and annealed during the operation in a non-oxidizing atmosphere, and therefore you get a worked surface all the way through that is free from oxide or free from slags or any other inclusions, whereas in the hot rolled stock, you roll the slag inclusions and everything else into it, and you have an entirely different surface. In one you can get a continuous coating, and in the other you get more or less of a porous coating.

MR. OPPLINGER: It would, to a certain degree, substantiate the claims there that the coating in that second illustration, which is bonded directly to the crystal structure, is the type of coating you would be more apt to get in hot rolled than in cold rolled stock.

MR. HOGABOOM: Rather it would depend upon that in hot rolled stock you have a surface that has a different conductivity. The slag or the carbon or anything that may be in that will resist the coating, and the current passing through the path of least resistance goes around that, and will gradually bridge over, whereas in cold rolled stock you have a surface that will give you a continuous surface or continuous electrodeposit, which will give you a better looking plate.

CHAIRMAN GRAHAM: Are there any other comments on this paper?—I should think the discussion would be very encouraging to the author. If there are no further remarks, we will proceed to the next subject.

In announcing the next topic, I would like to mention that while Mr. Hogaboom has pointed out that chromium-plating was not really a success until some of the variables involved in the preparation of the object prior to plating were overcome, chief among which was the bonding of the deposit itself to the base metal, that apart from that, there were two aspects to the development of chromium-plating which can be generalized upon, in this way. Chromium-plating introduced a different plating technique from the ordinary variety of plating which was known up to the time of its commercial introduction, and it concentrated attention on the importance of controlling the constituents minutely, and also of the relation between current densities and temperatures. On the other hand, the actual application of chromium in its early stages and in subsequent developments has also depended upon the ingenuity of the man actually doing the work, and that ingenuity varied with the man, and its demands varied also with the particular operation involved. Where relatively simple objects were being given a flash of chromium, there was little difficulty involved in how that coating was obtained over the entire surface. Or where it was a simple alloy that was being plated. But as the base metals varied or heat treatment varied, and as the configuration of the object varied, the ingenuity of the man applying the coating was called upon and came into play.

In introducing the next speaker, who is going to speak on the plating of chromium at high current densities, we are fortunate in having a man who is applying chromium-plating to a particular type of work, and his ingenuity has enabled him to accomplish certain results. Furthermore, the type of work that he is applying it to varies, not only in shape and in the uses to which it is put, but also in the alloys he must plate, and for that reason I am sure that what he has to tell us will be of particular interest. I take pleasure in introducing Lieutenant Willink, of the Frankford Arsenal.

LIEUTENANT A. WILLINK: *Mr. Chairman, Members and Guests*—I am going to discuss this subject of chromium-plating more from an economic viewpoint than from a strictly technical plating viewpoint.

In a previous paper, the speaker discussed modern practices in chromium-plating of tools and gages. Among those discussed was the use of a high current density in high temperature bath. It is the purpose of this paper to amplify and further discuss the economic possibilities of this method of plating, and then to discuss some present and future applications of chromium-plating.

While there is no natural line of demarcation between a low temperature plate and a high temperature plate, the properties of the high temperature plate which will be discussed refer to plates deposited in a bath of a temperature of about 160° F. compared to the common practice of plating from 100 to 135° F. The advantages and disadvantages of a high temperature and high current density plate will now be enumerated, and each discussed later, individually:

Advantages:

1. Wider plating range.
2. Better throwing power.
3. Increased current efficiency.
4. Faster rate of plating.
5. Less need for accurate control.
6. Reduction of surface film of oxide in plating operation.
7. Less porosity of plate.
8. Harder plate.

Disadvantages:

1. Larger generator capacity required.
2. Greater heating facilities required.
3. Difficulty of using stopping-off lacquers and products of a similar nature.

The fact that there is a greater plating range at high temperatures is made apparent by plotting the upper and lower limits of bright plate with respect to the temperature and current density. From this we can find that the plating range is about four times greater at 160° F. than it is at 105° F., and as the temperature goes up further the range increases in a greater proportion.

(See Interpolation 1.)

Better throwing power results from the greater plating range. It is only reasonable to suppose that where bright plate can be obtained within a wide range of current density increased throwing power results. As a practical illustration of this point: A

fixture was plated without an inside anode and the plating deposited down into the hole as well as in back of a mast.

There is a slight increase in the average current efficiency obtained, which can be seen by referring to the fundamental diagram of current efficiency and current density given by Schneidewind in Engineering Research Bulletin No. 10, of the University of Michigan. The better current efficiency is related somewhat to the better throwing power.

(See Interpolation 2.)

That a faster rate of plating is obtained is very easily seen by referring to the fundamental law of electrodeposition; i.e., that of Faraday, which says that the quantity of metal deposited is proportional to the current multiplied by the time; therefore, if the current is large, the time will be small.

The less need for accurate control is made clearer when a diagram giving the sulphate limit of a high temperature plate compared to a low temperature plate is studied. It will be seen that a current density range of approximately six times greater is obtained at 160° as compared with 105°. This means that the sulphate ratio can vary over quite a wide limit. The necessity for careful control of plate is made obvious under the discussion for greater plating range.

(See Interpolation 3.)

In the process of chromium-plating there is evolved a considerable amount of hydrogen, and this hydrogen is evolved in a rather active form. Since high temperature plates have been used, little difficulty has been experienced in plating chromium over chromium, or even over slightly oxidized surfaces of other metals, due to the fact that the effusive evolution of hydrogen reduces these oxides, either before or simultaneously with the plating operation.

The fact that a plate deposited at high current densities and at high temperatures is less porous was made known through the researches of Dr. Blum at the Bureau of Standards. It is by the discovery of this property that new possibilities for high temperature plate are opened up, and these will be discussed later in this paper.

Improved results on tools plated at high current densities and high temperatures indicate that the plate is harder and has better

physical properties. No quantity measurements were made until recently, when Piersol gives an indication of an increased hardness for a high temperature plate, based on the time for an abrasive wheel to cut through .001 inch of plate.

The first disadvantage is the large generating capacity required. This disadvantage is outweighed economically by the faster time of plating, and in cases where it is not feasible to put in larger generators, the progressive system of plating can be applied; that is, using movable anodes and plating portions of the cathode surface at a time.

The fact that more heating facilities are required is also compensated by the faster time of plating, and this disadvantage can be overcome at a very slight cost.

The difficulty in using stopping-off lacquers in a high temperature chromium bath has not yet been solved satisfactorily. Different stopping-off lacquers, varnishes and paints of various kinds have been tried. Some have been more successful than others, but the only practical means of getting around this is by the use of porcelain or glass, or by the use of metallic shields or thieves. Ordinary pine lumber is fairly satisfactory for insulating purposes in a chromium tank. The difficulty encountered with insulators is partially compensated by the better throwing power dispensing with them in many cases.

A general picture has just been given of the advantages and disadvantages of high temperature, high current density plating, which is the best known method of producing wearing surfaces on tools, gages, dies and a countless number of other industrial applications. In order that the audience may not be misled, it is only fair to state that in many cases of industrial application a successful application is not simply obtained by depositing a good chromium plate on the particular article. In many applications (particularly where pressure, impact and high temperature are involved) the proper choice of a basic material on which to deposit the chromium plate is of paramount importance. This basic material must not distort sufficiently under conditions of impact, pressure and high temperature, to cause the chromium plate to crack. In other words, it is similar to a building which is of no value unless it has the proper foundation. The mechanical design of the individual part influences the ultimate success of the chromium plate.

It would not give a true picture of the application of chromium plate to various tools not to admit that many problems have come up that have presented great difficulty, or with which success has not been obtained without great difficulty, and that there are others which at the present time have not been brought to a successful conclusion. However, all of these problems mainly deal with getting a suitable material to act as a foundation for the chromium plate.

It is in order for this paper to discuss some of the competitors of chromium plate. In tool and die work, nitriding has been used in several cases, successfully. As the cost of nitriding is reduced, it will offer strong competition to chromium plating, and chromium plating can hold its own only by efficient methods of plating and that unique property of chromium plate, whereby a wornout surface can always be replaced with a new one. In other words, the salvaging properties of chromium plate.

The use of tungsten carbide and similar materials has offered serious competition to chromium plate on tool and die work. A chromium-plated die did 100,000 pieces compared with 4,000 pieces done by an ordinary steel die; whereas a tungsten carbide die has done upwards of over a million and a half pieces. Studies are now being made to salvage this tungsten carbide die by means of chromium plating. In connection with tungsten carbide, as the cost of this material decreases, lower cost and more effcient methods of chromium plating are essential for chromium plating to stay in the picture. Other present and future competitors are:

Lining dies with hard material such as stellite and tungsten plating.

The lack of any definite information on these subjects makes it impossible to make any comment at this time.

Another new development is the carborization of chromium plate. In other words, a form of chromium carbide, which is said to be harder than chromium plate. No comments on this material can be made, owing to lack of data.

So much for the discussion of chromium and its competitors in the plating of tools and dies; and in conclusion, a few remarks will be made with reference to competitors of chromium in the decorative field, and to the possible application of high temperature plating in this field. A large automobile manufacturer has found it advantageous to replace chromium plating by the use of

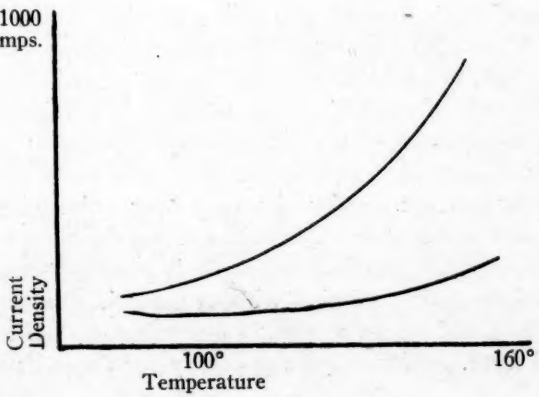
stainless alloys such as what is commonly called "eighteen and eight." The cost has been a factor that has been involved in this choice, but it is believed that the principal reason for the choice lies in the durability of the finish. The commercial thickness of chromium plate on automobile parts is about several hundred-thousandths of an inch, and it can easily be realized that a plate of this kind (while it has been found to be the least porous for plates deposited at ordinary temperatures and current densities) is thin, and consequently can be worn off by polishing, and it is also evident from Dr. Blum's work on porosity of chromium plate that plate deposited under ordinary temperatures has a sharp minimum when porosity is plotted against the thickness of plate; whereas at a higher temperature, the minimum is indefinite and runs over a wide range of thicknesses. It is reasonable, therefore, to suppose

(See Interpolation 4.)

that on irregular-shaped objects such as automobile radiators, lamps, etc., where the anodes do not conform to the contour of the piece being plated, a great many areas having thicknesses where the porosity is great will be obtained, and therefore early failure of the plate will result. From this it seems that the application of high temperature plate to decorative work will be valuable in meeting the competition of stainless steel and stainless steel veneer products. It will overcome present limitations of ordinary plate as to porosity throwing power and will be the means of giving chromium plating a slight advantage over its competitors.

Interpolations to Lt. Willink's paper:

(1) Diagram:



We will plot the current density and the temperature here. Of course remember, the data from which this was taken depended on somebody's judgment as to what a bright plate was. The man I originally took this data from is Schneiderwin in his very excellent bulletin, issued by the University of Michigan. A similar curve to this is in the Bureau of Standards Paper No. 346. You will observe that the current density range is considerably greater at this higher temperature than it is at the lower one. That is the first advantage of this high temperature plate.

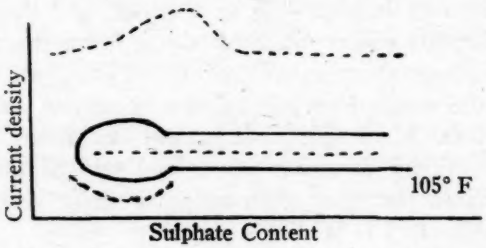
Now, as the temperature goes up further, this range (between the two curves) will increase in a still greater proportion.

I might say that all this discussion refers to the solution proposed by the Bureau of Standards, of 33 ounces of chromic acid per gallon, and a sulphate ratio of about 100 to 1.

(2) Let me give a practical illustration of this point.

(Shows samples of plated work.)

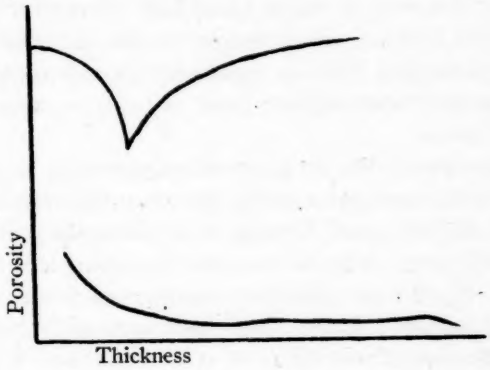
(3) Now, the less need for accurate control is made clear when I draw a diagram here. (Diagram.)



You will get limits of bright plate that are very narrow, for a bath at about 105° F., and you will get wide limits, a curve that will look something like that. The actual limits of that curve are not very well defined, but the point I want to make is that the necessity for careful control of the sulphate is eliminated. And this data was also taken from Schneiderwin's paper at the University of Michigan. Also, look at this first curve that I drew, and note that your current density can vary over quite wide limits, and so can your temperature. You have got absolutely no necessity for hair line control. In other words, it is perfectly possible to run a chromium-plating solution without control. You can judge the temperature and get away with it, providing you have enough temperature there. And also, your necessity for frequent analysis

is eliminated. Ordinarily, of course, it is good practice to control your solutions.

(4) I can make myself clear when I take a diagram Dr. Blum has drawn in his recent work on porosity. He has a diagram something like this:



For ordinary temperatures, he gets a curve like this (upper curve) with a very sharp minimum, and then it goes up in porosity, and for the higher temperature plates, the minimum is very poorly defined. In other words, they are indefinitely defined. What I mean by that is, in the ordinary process of plating at low temperatures your current density is not uniform all over the piece. Consequently the thickness of the plate will not be uniform all over the piece. Remember, we will get a deposit all right, but there will only be part of that deposit that will be at this optimum thickness (indicating bottom of "V" shaped curve) for the low temperature plate.

You can readily see from this curve here (indicating last curve), that if you are running a current density that will give you various thicknesses in this region (indicating at extreme right of lower curve) that the porosity will be somewhere near equal. In other words, you will get a plate that will stand up better.

[Applause]

MR. PROCTOR: I would just like to ask for a point of information what the maximum temperature that you use is—the greatest temperature?

LT. WILLINK: Well, due to physical encumbrances, that is the maximum we are able to get practically on our heating system,

and when I get some more money I will get a better heating system. That used consistently is about 160 degrees, but we would like to go higher.

MR. PROCTOR: The reason I ask the question is that I have done some work myself at 165, and I think I can bear you out that you do get better throwing power at those high temperatures.

DR. BLUM: Might I call attention to the fact that, as far as porosity is concerned, there is apparently no advantage in going to higher temperatures because your porosity is almost zero at about 160 degrees.

MR. OPPLINGER: I had an interesting experience some time ago which somewhat bears out some of the claims Lieutenant Willink has made. I had the good fortune to see some chromium plating done on a very large scale; in fact, the firm doing the plating used several tons of chromic acid per month, and while they didn't use high temperature baths, they used extremely high current densities. The plating was all done at 12 volts, and I don't think at any time there was more than possibly two square feet of work surface in one tank, usually about 200 gallons capacity. Just what the current density was, I am not able to state, except it must have been 700, 800, or possibly 1,000 amperes per square foot. The plating time was never more than ten seconds, usually maybe a second or so less. The man just simply took the work and counted 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and pulled it out and it was done. And there is a great quantity of work being done just that way, particularly on refrigerator hardware and on screws. That particular firm had to plate anywhere from 200,000 to 300,000 screws per day, and they couldn't afford to waste any more time on the work in one tank than was absolutely necessary to get a good plate.

Now, what the efficiency of a chromium-plating solution at 700 or 800 or 1,000 amperes would be, I don't know. But I think it is perfectly safe to assume that with the high currents they put on just as much chromium as many of them do at 100 amperes per square foot, or whatever might be the normal low current density, low temperature bath.

CHAIRMAN GRAHAM: Of course, there is a relation between temperature and current density, but as Lieutenant Willink pointed out, as you vary your current density, the possible variation of temperature is greater. They were probably within the limit of getting a satisfactory plate. Do you know the temperature?

MR. OPPLINGER: Mr. Proctor might know.

MR. PROCTOR: 110 degrees. Time of plating, 9 seconds.

MR. BOOTH: I would like to know how far the temperature would be a factor in plating direct on metal without nickelplating.

LT. WILLINK: Practically all our work is direct on steel.

MR. BOOTH: I refer mostly to brass.

LT. WILLINK: I am not prepared to make a statement on that yet. It may have possibilities, but I wouldn't commit myself. What you are driving at is that you eliminate the nickelplating over brass.

MR. BOOTH: The Hays Plumbing Supply people in Erie, they do all their chromium plating direct on the metal. They use no special anodes of any kind, and use a very low current density and a very low temperature, more so than if they nickelplated. They are doing away with their nickelplating tanks and chromium plating direct. The reason I asked you that was to find whether you had some information as to whether that very high current density and temperature would be an advantage over the low.

LT. WILLINK: All I can go by in answering that question is what Dr. Blum has found out at the Bureau of Standards, and I would be a little skeptical myself as to the ultimate outcome. However, I am not in a position, not having done that particular type of work, to really give you an accurate prophecy of what would happen.

CHAIRMAN GRAHAM: Might I ask the last speaker, in reporting upon that low temperature, low current density deposit, whether they were getting a dull deposit and polishing afterwards?

MR BOOTH: They claimed they were using the low current density, low temperature method to get a bright polish. Where they use temperatures of 105 to 113 degrees, they have to buff it. It comes out in a gray finish. But where they use the lower temperature of about 60 to 65 and a low current density, it comes out bright. The current density, I believe, was about 40 amperes per square foot. It comes out with a luster requiring little buffing.

MR. DIMON: You mentioned the possibilities of applying this to automobile work. Wouldn't that lift the nickel?

LT. WILLINK: I couldn't answer that question. As I said, I was getting a little out of my line, but it looked good to me.

CHAIRMAN GRAHAM: Are there any other comments? If not, we will adjourn.

THE PRESIDENT'S LETTER

As we stand at the threshold of a new year let us take an inventory of the accomplishment of our Society during the past year and a perspective of the coming year.

During 1931 we had three goals, namely, to further the education of the members in the art of electroplating, to find solution to many problems common to all platers, and to have the American Electro-Platers' Society recognized by other technical societies.

The formation of chemical classes by many branches has been of untold value to the individual.

The large number who have enrolled in these classes shows that the members feel they need further chemical knowledge. Let the year 1932 see the continuance and expansion of such classes, so that electroplating may become a science or an art rather than a deep mystery.

The innumerable requests for advice, information and co-operation from other technical societies prove that we have won their recognition and respect.

The Bureau of Research has solved several of our difficult plating problems. A large project involving the plating of 7000 pieces of work has been started. After these pieces have been plated they will be sent to various parts of the United States to be exposed on the exposure racks of the American Society of Testing Material. When the final tests have been completed the scientific data concerning this experiment will be broadcast to the member. This will enable any plater to secure the same results in any plating room. This work of course requires money to support it. Due to the closing of the bank in which the research funds are kept, it will be impossible to carry on this work unless every member will put forth a special effort to help raise emergency funds.

Therefore let us strive this coming year to foster and strengthen the work of the Research Committee even though it means a personal sacrifice on the part of each member.

BRANCH NEWS

NEWARK BRANCH

The regular meeting was held on Friday, December 3, 1931, at the Newark Elks Club, Broad Street, Newark, N. J.

President William Harrison called the meeting to order at 8:45 p. m., there being 31 members present.

President Harrison appointed Mr. Samuel Taylor chairman of Banquet Committee to be held the Saturday after Easter. Other members of the committee: Entertainment, Mr. H. Smith, Mr. C. J. Sizelove. Program Committee, Mr. George Wagner, Mr. Bert Sage. Tickets, Mr. Groh. Educational Committee, Mr. Paul Aldam, Mr. George Reuter, Treasurer.

Under good and welfare it was voted to help out some poor family, which has been the custom of Newark Branch in the last few years. And help some poor kiddies enjoy Christmas.

Under papers and discussion, our Educational Secretary, Mr. Paul Aldam, introduced Dr. Wm. Mantell of Pratt Institute of Brooklyn, N. Y.

Dr. Mantell's subject was, The Refining of Metals, and he brought out many important points of plating, one of which was, Why does the plater not think in cost of power or, in other words, many platers lose power through poor connections, resistance in solutions and overvoltage. Where in case the refiner has mastered or at least has been able to overcome most of those power losses because of power cost, and proved to the members assembled that the refiner not the plater has brought to the fore many if not all new metal solutions found in the last few years.

Dr. Mantell's talk was one of the best yet heard at the Newark Branch and brought out many truths about the plater and all the members attending resolved to look to their power losses more carefully after hearing Dr. Mantell's talk.

Many questions were asked and explained by Dr. Mantell, such as: Voltage drop between anode and cathode; voltage drop across solution; external resistance, contact drop, anode resistance.

Meeting adjourned at 10:15 p.m.

The Newark Branch has new meeting quarters at the Elks Club, Newark, big and finely furnished with big comfortable chairs where one can enjoy the meetings with all the comforts of home.

GEORGE REUTER, *Secretary.*

DETROIT BRANCH

Detroit Branch held its regular monthly meeting at the Statler Hotel on December 4 with the President, Jos. H. Hansjosten, in the chair. Secretary Chas M. Phillips was absent and Mr. George Kutzen was appointed secretary pro tem.

Due no doubt to the inclement weather a number of members were absent. They missed a treat by not hearing a paper by Mr. Gustaf Soderberg, entitled: "Some Experiences in Servicing Plating Solutions." Mr. Soderberg's

paper touched on the many and varied difficulties encountered in the plating room and suggestions for overcoming them. It contained many practical hints to the plater, not only on how to overcome trouble, but on how to anticipate it and avoid it.

The January meeting will take place on the 8th of that month. Mr. Geo. Dupernell will present a paper entitled "Adhesion" at that meeting. Our members are advised not to miss this meeting, for anything about plating by Mr. Dupernell is worth while.

Until further notice all communications to Detroit Branch should be sent to Mr. George Kutzen, Acting Secretary, 1087 State Fair Ave., Detroit.

The Chairman of our Educational Committee, Mr. B. F. Lewis, was absent, and Mr. Chas. E. Marker conducted the Question Box, which contained the following questions.

Question—Is a magnetized piece of steel more difficult to plate than pieces that are non-magnetic? Is a magnetized steel piece more likely to get a rough nickel coat?

Answer—Suspended particles of nickel or iron frequently present in nickel solutions would undoubtedly cause a rough deposit, particularly on magnetized work.

Question—What is the best throwing nickel solution, on steel and on copper?

Answer—The solution containing a large amount of sodium sulphate, such as is used for plating die castings would probably give maximum throwing power, but the deposit is more porous and otherwise inferior to that obtained from the Watts type of solution which, at high pH, should give adequate throwing power on steel and copper.

Question—What is the fundamental principle of electrodeposition of metals upon other metals; that is, what makes the deposit adhere?

Answer—This question will be answered in a paper to be presented at the January meeting by Mr. George Dupernell.

Question—What conductor is recommended for cadmium solutions? Also, what operating temperature?

Answer—Sodium cyanide, and room temperature.

Question—What is the most efficient brightener for cadmium solutions?

Answer—Organic substances such as evaporated milk, postum, etc. These and others are covered by various patents.

B. F. Lewis, *Chairman,*
Educational Committee.

MILWAUKEE BRANCH

The regular meeting of Milwaukee Branch was held December 10, 1931, at Lipps Hall, 3rd and W. Highland. The meeting was called to order by President M. Nishwitz, all officers being present. Mr. Henry Binder was appointed as Milwaukee Branch representative on the Bureau of Education. Milwaukee Branch voted $50.00 to the Research Fund.

Wanted:—Formula for depleting solution. For aluminum casting containing some silicon. Anyone knowing of a good formula please write Secretary, Milwaukee Branch.

Frank J. Marx, *Secretary-Treasurer.*

LOS ANGELES BRANCH

The regular monthly meeting of this branch was held November 18, on the ninth floor of the Chamber of Commerce Building. The meeting was called to order with President E. W. Francis presiding and all officers present.

Almost half of the branch's membership turned out for the meeting—43 to be exact. All communications were read and ordered filed. Bills ordered paid. It was moved and seconded that this branch carry its members whosoever may be out of employment until such time as he may be employed again.

The meeting was turned over to Earl Coffin, Librarian. The following question was found in the Box:

"What is the nature of the judgment in favor of the United Chromium Corp., and in what way will this decision affect chromium platers who have no license?"

This question caused considerable discussion and the members of the L. A. Branch would like to have an opinion on this matter from the other branches.

A copy of the letter below was sent to the Secretary of each branch, appreciating the fact that the REVIEW had already gone to press.

Dear Secretary:

We would like to have the following question brought up at your meeting, to wit:

"What is the nature of the judgment in favor of the United Chromium Corp., and in what way will this decision affect chromium platers who have no license?"

We feel it is a very vital question since it eventually may lead to the chromium industry being controlled by a group who are interested from a selfish standpoint and not working to the advancement of the electroplating industry, therefore, the reason for asking your branch to help out with this question.

We extend the kindest regards and the season's greetings to the members of your branch.

Yours very truly,

M. D. RYNKOFS, *Secretary.*

CLEVELAND BRANCH

Cleveland Branch held its monthly meeting on Saturday evening, December 5, at Hotel Winton, Vice President H. J. TerDoest presiding.

The minutes of the November meeting were approved as read.

Mr. Zadowski, chairman of the chemistry class committee, gave a report on the attendance, stating that the first night 17 members attended but that only 10 members came regularly. The committee thinks that, as this is free to the members, more should avail themselves of this opportunity. Dr. Prutton's methods of control are easy to use and are practical, having been in use in Cleveland plants for the past 7 years. The Committee hopes that more members will attend this class as it is not too late yet.

Our Librarian, Mr. Stroh, read a paper on Finishing Aluminum. Mr. A. G. Spencer of Detroit spoke on the pickling of steel.

A motion to adjourn was carried at 10 p.m.

PAUL STAMM, *Secretary.*

WATERBURY BRANCH

"From Mine to Consumer" was the drawing card that interested the members of Waterbury Branch at their meeting, Friday evening, December 11th. Although the weather was anything but ideal, a good attendance was on hand and enjoyed the treat which was presented through the courtesy of The American Brass Company. It was the first opportunity that many of the members had of witnessing how the mining and refining operations of the Anaconda Copper Mining Co. are worked out in Montana. No less interesting were the scenes taken from the various manufacturing plants of the American Brass Co. Of special interest was the picture showing copper alloyed with electrolytically pure zinc in the making of brass. At the conclusion of the picture the branch extended a vote of thanks to the American Brass Co., for the presentation of the film, and to Mr. Miller, the operator.

In the absence of Ellsworth Candee, Earl Couch gave a report on the progress of the chemistry class, which started in Wilby High School, Tuesday, December 1st. The instructors are Ellsworth Candee and Earl Couch and up to the present time about twenty of the members have put in an appearance at the meetings.

The possibility of a joint meeting between Bridgeport-Hartford-Connecticut Valley Branch and Waterbury was discussed, but no definite action was taken, awaiting further details. A communication from the Los Angeles Branch relative to the subject of "Chromium Plating" was received and read. After a little discussion on the matter, the secretary was instructed to acknowledge the receipt of same. Librarian Wm. Cavanaugh announced that arrangements are under way for a talk and exhibit at our next meeting, Friday, January 8th, of fancy and decorative metal finishing. This subject is bound to be instructive and interesting, and should bring out every member of the branch.

WM. H. GUILFOILE, *Secretary.*

CHICAGO BRANCH

The regular monthly meeting of Chicago Branch was held December 12, 1931, at the Atlantic Hotel. The meeting was called to order with President J. C. Kretschmer presiding and all officers present.

This was a very interesting meeting. There were some very good questions asked and a great deal of knowledge was gained.

All members who did not attend this meeting sure missed a treat.

We had a very large attendance, 85 members present.

Mr. S. E. Huenerfauth, Chairman of the Banquet Committee, reported that all arrangements for the Educational meeting and Dinner Dance will be held at the Congress Hotel Gold Room, February 20th, 1932.

The Educational Committee, Mr. O. E. Servis, Chairman, promises a very good Educational Session.

Mr. H. A. Gilbertson, Chairman of the Chemistry Class, reported class will commence January 19th, 1932. All members who want to join this class be sure to attend the meeting Saturday, January 9th, 1932.

All laboratory work will be demonstrated by Mr. H. W. Faint.

The business part of the meeting having been taken care of, the meeting was turned over to the Librarian, Mr. O. E. Servis, and the following questions were found in the Box.

Question—How can water spots be avoided on polished chromium; would like to eliminate the buffing?

Answer—One member suggested spray plenty cold water, then dry in hot air oven.

Question—A cyanide copper solution was operated for one month, no copper cyanide was added, some sodium cyanide was added, analysis shows metal content had increased. What may be reason?

Answer—Copper will increase in ordinary temperature, when working with free cyanide metal will build up, remove 50% of copper anodes and replace with steel anodes.

Question—How can a hard chromium plate be produced that will resist abrasion? Decorative properties not of interest.

Answer—Raise current density, lower metal content.

Question—Can lead, nickel or iron be deposited in a cyanide copperplating solution, if used at anodes?

Answer—You can find traces of lead if you use it as a brightener.

Question—What is the so-called cold chrome-plating process; does it compare with the hot solution?

Answer—Do not think you could get a hard deposit in cold solution, no advantage.

Yours very truly,

E. G. STENBERG, *Secretary.*

ROCHESTER BRANCH

On Friday evening, December 18, Rochester Branch held their monthly meeting at the Hotel Seneca with President Hart in the chair. Our members were shocked by the sudden death of one of our members, Mr. William Wolfe, who was stricken without warning at his work. Mr. Wolfe will be missed by Rochester members. He was always ready to help any and all members of the A. E. S. Secretary was instructed to send a letter of sympathy to Mr. Wolfe's family, also to drape charter for 30 days.

Rochester Branch have their chemical laboratory ready and Mr. Lux looks for a big year with his chemical class. Any of our out-of-town members are welcome to our school chemical class. They meet every Wednesday night.

CHAS. GRIFFIN, *Secretary.*

APPLICATIONS

M. F. DUNLEAVY, 2660 North Avenue, Bridgeport, Conn.....Bridgeport
J. ST. PIERRE, 21 Lawson Road, Bristol, Conn.....Hartford-Conn.
R. L. HOENSTINE, Mt. Wolf, Pa.....Philadelphia
A. E. SHAFFER, 1328 N. 13th Street, Philadelphia, Pa.....Philadelphia
H. S. HARDWICK, 3257 Madison Street, Alameda, Cal.....San Francisco

ELECTIONS

M. F. DUNLEAVY, 2660 North Avenue, Bridgeport, Conn.....Bridgeport
J. ST. PIERRE, 21 Lawson Road, Bristol, Conn.....Hartford-Conn.
R. L. HOENSTINE, Mt. Wolf, Pa. (Associate).....Philadelphia
A. E. SHAFFER, 1328 N. 13th Street, Philadelphia, Pa.....Philadelphia
H. S. HARDWICK, 3257 Madison Street, Alameda, Cal.....San Francisco

SUSPENSIONS

MR. CHAS. LEE, 1625 Lincoln Avenue, Lakewood, Ohio.....Cleveland
F. D. HYDE, 1172 E. Slauson Ave., Los Angeles, Cal.....Los Angeles
R. BUCHANAN, 2124½ S. Vermont Avenue, Los Angeles, Cal....Los Angeles
M. MCBENNETT, 2278½ W. 28th Street, Los Angeles, Cal.....Los Angeles
J. SHULMAN, 6639 Lexington Avenue, Hollywood, Cal.....Los Angeles
T. H. MCCLAIN, 428 N. Louis Street, Glendale, Cal.....Los Angeles
J. A. ROBINSON, 123 N. Grand Avenue, Los Angeles, Cal.....Los Angeles

TRANSFER

MR. A. W. KONDNER from Baltimore-Washington Branch to Philadelphia Branch.

DEATHS

J. J. DOUGHERTY, 2093 E. Pickwick St., Philadelphia, Pa.....Philadelphia
E. W. FOSBURG, 11 First Avenue, Halethorpe, Md.....Philadelphia

In Memoriam

MR. WILLIAM WOLFE

ROCHESTER BRANCH

RESEARCH COMMITTEE

Chairman, JACOB HAY.....6920 Ottawa Ave., Chicago, Ill.

Sec.-Treas., WALTER FRAINE.....507 Grand Ave., Dayton, Ohio

S. E. HEDDEN.....227 Fifth Ave., Aspinwall, Penn.

WILLIAM F. GUILFOILE.....14 Oakland St., Waterbury, Conn.

DAN WITTIG.....1221 N. Third St., Milwaukee, Wis.

DR. WILLIAM BLUM.....Bureau of Standards, Washington, D. C.

MR. OSCAR SERVIS.....5305 Warner Ave., Chicago, Ill.

MR. N. E. ZADOWSKI.....1383 W. 65th St., Cleveland, Ohio

MR. W. S. BARROWS.....628 Dovercourt Road, Toronto, Canada

C. F. NIXON.....Ternstedt Manufacturing Co., Detroit

DR. H. S. LUKENS.....University of Pennsylvania, Philadelphia, Pa.

BUREAU OF EDUCATION

Chairman, MR. ALBERT HIRSCH.....1945 Airdrie St., Philadelphia

Branch Representatives:

Chicago Branch.....HAROLD FAINT

Waterbury Branch.....ELLSWORTH CANDEE

Los Angeles Branch.....M. D. RYNKOFS

New York Branch.....HENRY LEVINE

Philadelphia Branch.....DR. A. K. GRAHAM

Baltimore-Washington Branch.....DR. WM. BLUM

Cleveland Branch.....J. C. SINGLER

Hartford-Connecticut Valley.....RAY O'CONNOR

Worcester Branch.....M. H. FROMMANN

Toronto Branch.....C. KEMESH

Anderson Branch.....D. A. COTTON

Newark Branch.....PAUL A. OLDAM

Milwaukee Branch.....HENRY BINDER

Other Branch Representatives will be printed as received.

ANDERSON BRANCH

Meets first Monday of every month at 7:30 p.m. at the Anderson, Indiana, Y. M. C. A. R. M. Wagner, Secretary-Treasurer, 28 W. 12th St., Anderson, Indiana.

BALTIMORE-WASHINGTON

Meets in Enoch Pratt Library, Calhoun and Hollis Sts., Irvin H. Hahn, Secretary, 207 S. Sharp St., Baltimore, Maryland.

BOSTON

Meets at American House, Boston, Mass. First Thursday each month. Secretary, A. W. Garrett, 45 King St., Dorchester, Mass.

BRIDGEPORT

Meets first and third Friday of each month at Chamber of Commerce Rooms, Stratfield Hotel. Secretary, T. H. Chamberlain, 859 Orange St., New Haven, Conn.

CHICAGO

Meets second Saturday of each month, at 8 p.m., Atlantic Hotel, 316 S. Clark St., Secretary, E. G. Stenberg, 2200 N. Kenneth Ave., Chicago, Ill.

CINCINNATI

Meets every Thursday, 7.30 p.m., at Vocational Training School, Spring and Liberty Sts. Secretary, Al Yeager, 2021 Sherman Ave., Norwood, Ohio.

CLEVELAND

Meets first Saturday of each month at Hotel Winton. Paul R. Stamm, Secretary, 947 Elbon Road, Cleveland Heights, Ohio.

DAYTON

Meets first Saturday of each month at the Y. M. C. A., Dayton, Ohio. Secretary, Ward Protsman, 141 Westwood Ave., Dayton, Ohio.

DETROIT

Meets the first Friday of each month at the Hotel Statler, Louis II Room. Secretary, Chas. M. Phillips, 18933 Hickory Ave., Detroit, Mich.

GRAND RAPIDS

Meets second Friday of each month at 528 Lake Michigan Drive, N. W. Secretary, Jacob Van Dyke, 1361 Union Ave., N. E., Grand Rapids, Mich.

HARTFORD-CONNECTICUT VALLEY

Meets fourth Monday in each month alternately at the Chamber of Commerce, 815 Main St., Hartford, and the Chamber of Commerce, 134 Chestnut St., Springfield. Secretary, Vernon Grant, 32 Jennings Road, Bristol, Conn.

INDIANAPOLIS

Meets second Saturday of each month at Hotel Denison. Secretary, Louis Mertz, 1725 Union St., Indianapolis, Ind.

LOS ANGELES

Meets second Wednesday of each month at the Chamber of Commerce Bldg., 9th floor, 1151 S. Broadway. Secretary, M. D. Rynkofs, 1354 W. 25th St., Los Angeles, Calif.

MILWAUKEE

Meets second and fourth Thursdays of each month at Cor. 3rd and Highland Ave., Frank J. Marx, 1431 W. Cherry St., Milwaukee, Wis.

MONTREAL

Meets second and fourth Friday of each month at 1437 Aylmer St., Montreal, Quebec, Canada, where the Secy-Treas., Mr. Charles Doherty, can be found at any time.

NEWARK

Meets first and third Fridays of each month at Newark Elk's Club, Broad St., Newark, N. J., at 8 p.m. Secretary-Treasurer, Geo. Rueter, P. O. Box 201, Newark, N. J.

NEW YORK

Meets second and fourth Fridays of each month in the World Building, Park Row, New York City, N. Y. Secretary-Treasurer, J. E. Sterling, 2581 46th St., Astoria, L. I.

PHILADELPHIA

Meets first Friday of each month in the Harrison Laboratory Building, University of Pennsylvania, 34th and Spruce Sts. Secretary, J. E. Underwood, 327 N. 10th St., Camden, N. J.

PITTSBURGH

Meets first Friday of each month at 8 p.m., at downtown branch, Y. M. C. A. Secretary, S. E. Hedden, 227 Fifth St., Aspinwall, Pa.

PROVIDENCE-ATTLEBORO

Meets first and third week of each month. Notice by card. J. H. Andrews, Secretary, 19 Rosedale St., Providence, R. I.

ROCHESTER

Meets third Friday of each month at Hotel Seneca. Secretary, Chas. Griffin, 24 Garson Ave., Rochester, N. Y.

SAN FRANCISCO BRANCH

Meets at Plaza Hotel, San Francisco. Secretary, H. W. McKibben, 310 Tehama St., San Francisco, Cal.

ST. LOUIS

Meets second Friday of each month at the Plant of the Lassalco Co., 2828 LaSalle St. Secretary, C. T. McGinley, 8214 Fairham Ave., University City, Mo.

TOLEDO

Meets first Thursday of each month at Toledo Secor Hotel, Cherry and Page Sts. James M. Lee, Secretary, Barker Street, Fremont, Ohio.

TORONTO

Meets fourth Monday of each month at Canadian Foresters' Hall, 22 College St., Room No. 2. Secretary, H. W. Graham, 102 Robina Ave., Toronto, Canada.

WATERBURY

Meets second Friday of the month at Engineers Hall, No. 11 East Main Street. Wm. F. Guilfoile, Secretary, P. O. Box 961, Waterbury, Conn.

WORCESTER

Meets Directors' Room, Chamber of Commerce, Worcester, Mass. Roger H. Bryant, Secretary, 94 Grove St., Worcester, Mass.